Weather Event Simulator

Simulation Guide:
June 29, 1998 Event

Presented by the

Warning Decision Training Branch

Acknowledgements

Document History

The document history is provided to track updates and changes to the simulation guide. The version number, seen at the bottom of every page will be updated as each significant change is made to the simulation guide.

Version	Date	Description
1.0	29 Mar 2002	Initial release.
1.0a	30 Apr 2002	Minor correction on page 1-1. (Note: For the printed version of this document, a page insertion change may have been accomplished. In that case, only pages iii, iv, 1-1, and 1-2 will display "Version 1.0a".)
1.0b	30 Apr 2002	Typographical error correction: page iii.

Note: the date of modification is listed on the cover page.

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1: How to Use This Document

I.   Introduction

Welcome to the ***June 29, 1998*** simulation guide! The purpose of this guide is to provide the trainer at a forecast office with guidance on preparing and delivering effective severe weather simulations using this case. This guide is being released in accordance with the Weather Event Simulator Integration and Operations Plan (WES IOP).

> ***Since this document outlines the "answers" to the challenges of the event, it is specifically meant for the use of the trainer only.***

A simulation can be as simple (view data and practice using WarnGen) or as involved (pause simulation to discuss warning decisions and the impacts of all data on these decisions) as needed. ***The simulation length can be modified depending on the time available for training, the needs of the trainee, and the focus of the training.*** The simulation can focus on the technology alone, the science alone, or the interactions between these two and the human decision maker (i.e. simulating an actual event). This guide is the second in a series of training guides, each associated with specific cases identified in the WES IOP. With this guide, the trainer can summarize the key points of a particular case, choose the type of simulation appropriate for the trainee, and then see an example of how to run that simulation type.

See Table 1-1 for a description of the layout of this document.

Table 1-1: Simulation Guide Layout

How to Use This Document	
Introduction	The introduction describes contents of the simulation guide and how to use this document.
Simulation Types	This section provides a brief, generic description of the various simulation types, some of which are presented in this document. Read this section to help you decide which type of simulation best fits the needs of the trainee (e.g., one which focuses on interpretation skills, or the use of AWIPS, or timing capabilities, or all the above).

Table 1-1: Simulation Guide Layout

The June 29, 1998 Event	
Overview	The event overview provides a summary of the key components of this event. Read this section to get a brief overview of the type of weather or challenges associated with the case.
Prepared Simulations	
Interval Based Simulation, Situation Awareness Simulation, Virtual Reality Simulation, Case Study Simulation	Prepared simulations are provided in this portion of the simulation guide. Each one contains directions on when to start/stop the simulation, objectives, tasks, expected results, and talking points to help hone in on certain features.
Supporting Data	
Storm Reports	Storm Reports contains a graphical plot of Storm Data and a text list of Storm Data valid for the simulations.
SPC Products	SPC Products contains graphical plots of the watches/outlooks and text discussion SPC products.
Support Materials	Support Materials contains a CWA map and a useful form for documenting issued warnings and advisories.

To prepare to run a simulation, the trainer should read **How to Use This Document** as the background necessary to choose and deliver effective simulations. The trainer may wish to modify the provided simulations, or develop their own simulations with specific learning objectives. The prepared simulations are the "scripts" designed for one-on-one training, where **trainer and trainee participate together for the optimum learning experience**. Training research indicates this is the most effective way to run a simulation. Experience gained from running simulations can be used to guide future training activities.

In order to manage a simulation session, the trainer must be able to run a simulation as documented with the WES install and testing instructions included with the WES software. The simulations will be much more relevant if local WarnGen templates and procedures are created on the WES machine or moved over from the local AWIPS prior to running the simulations. For more detailed information on these techniques as they become available, visit http://www.comet.ucar.edu/strc/wes/.

II.   Simulation Types

Interval-Based Simulation

An interval-based simulation focuses on detailed discussions of critical warning points utilizing pauses in the simulation. The training objectives are to demonstrate methods of data interpretation, effective use of AWIPS data, proper type and content of warnings, and weighing information in the decision making process. In addition, the trainee should demonstrate ways to handle uncertainty in the warning decision making process.

The objectives of the interval-based simulation are achieved by the **trainer and trainee** working together through a simulation that is occasionally paused to invoke the question-and-answer process. Direct observation of actions taken by the trainee during important decision points during the simulation can provide excellent opportunities for the trainer to discuss applications of effective warning decision making.

Situation Awareness Simulation

A situation awareness simulation focuses on evaluating the trainee's ability to maintain *three levels of situational awareness*. These are:

1. **Perceive** the warning inputs (*e.g., A spotter reports rotation*),

2. **Comprehend** the meaning of these inputs (*e.g., Together with velocity information, this indicates a high probability of a tornado.*),

3. **Project** this meaning into expectations and action (*e.g., A tornado warning is required along and slightly to the right of the storm's path.*).

For this level of simulation, the trainer will occasionally pause the simulation to query the trainee on interpretation of events. Through this process, the trainer attempts to deduce whether the trainee is maintaining all three levels of situation awareness. The training objective at this level of simulation is to *demonstrate awareness of the situation*.

During this type of simulation, the pausing or "freezing" of simulated data (at an unannounced time) provides an opportunity for the trainer to assess the level of

situation awareness that the trainee has of a given situation by asking three questions:

1. Does the trainee recognize the data? (e.g. are they aware of all potentially severe storms?)

2. Does the trainee understand the meaning of the data? (V_r of 50kts, strong backing low-level winds, etc.)

3. Has the trainee formed an expectation based on these data?

As in the interval-based simulation, monitoring of the trainee's level of situation awareness and subsequent decision-making process is only achieved via the trainer's questioning on the methodologies and conceptual models used in the decision-making process.

Virtual Reality Simulation

The virtual reality simulation mode is intended to most closely resemble what can happen in the office for a real event. The training objective of the virtual reality simulation is to effectively manage all aspects of a challenging and distracting warning environment while still producing quality products. For example, the trainer might provide conflicting information (spotter reports without supporting radar data) or interject problems (primary radar data unavailable) that the trainee has to react to and overcome during the simulation. This simulation focuses on the highest level of performance and critical thinking skills that should be present with an expert warning forecaster. Running the expert forecasters on staff first through the virtual reality simulation may be a good place to start using WES to enhance a local training plan. Experiences in this simulation can be used to incorporate local knowledge and expertise into future simulations for others forecasters on staff.

Case Study Review

The case study review is appropriate for simulating analysis and manipulation of data sets, including longer-fused events (such as a developing winter storm). Objectives for this type of training depend on the type of event and the forecast problem (boundary analysis, precipitation type forecasting, model initialization, etc.). Training objectives should be based on demonstration and recognition of the strengths and limitations of the various data sets and procedures which are best used to make the watch or warning decision.

The *June 29, 1998* Event

Overview

On the late morning and afternoon of June 29th, 1998, a significant severe weather outbreak occurred over Iowa. This was a moderate risk situation with the potential for significant severe weather, including tornadoes, large hail and severe winds. The 0 - 6 km wind shear of greater than 50 kts, and the expected very large instabilities (CAPE > 4000 j/kg), suggested the predominant convective mode would be supercells with very large hail and some tornado potential. However, weak 0-3 km shear and weak low-level flow magnitudes argued for outflow dominated supercells. After a late morning initiation, the convection evolved into a severe Mesoscale Convective System (MCS). Supercell structures embedded within the leading edge of the MCS produced widespread extremely severe wind swaths of greater than 80 kts. One of these swaths swept through the Northern and Eastern sections of Des Moines, IA producing damage equivalent to an F2 tornado. Several tornadoes were also reported with the embedded supercells in the MCS. Several counties also reported minor urban and small stream flooding. Contrary to earlier expectations, there were few reports of significant hail beyond one inch in diameter.

This event presents interesting challenges in that the resultant severe weather is somewhat different than expectations made when the storms were beginning to develop in the late morning. A unique aspect of this event includes being able to properly anticipate and react to the evolution of a derecho with extreme surface winds, embedded tornadoes, rapid motion and unexpectedly small hail. For a plot of storm data and the report list, see Appendix A.

2: Interval Based Simulation

I.   Introduction

This simulation allows the trainee to develop critical thinking skills. To that end, the trainer and trainee should come to consensus through discussion when arriving at decision points.

The simulation focuses on the unique aspects of handling warning responsibility for a warning sector containing the birth of a severe MCS with embedded super-cells. All severe weather threats are possible. At various points in the simulation, the WES trainer will pause the simulation and query the trainee about specific learning points. The trainer and trainee should discuss decisions based on the available information and expected outcomes. This simulation is appropriate for a warning forecaster who is proficient at issuing warnings and can benefit from practicing handling conflicting information and challenging warning workloads.

Objectives

The training objectives of this interval-based simulation are:
- Demonstrate effective methods of data interpretation.
- Demonstrate proper type and content of warnings.
- Demonstrate how to weigh information and handle uncertainty in the warning decision making process.

Responsibilities

Support materials in sections I (Introduction), II (Pre-simulation Briefing), III (Simulation), IV (Post-simulation Briefing), and V (Trainer Evaluation Guide) have been designed for a two person training session with the following responsibilities:

Trainee

Pre-Brief: Analyze the environmental data, issue a briefing detailing the threat for all severe weather types, and discuss sectorizing the county warning area.

Simulation: Issue warnings and follow up statements for a sector covering the storms in northeast part of the CWA.

Post-Brief: Discuss with the trainer any lessons learned and how they can be implemented at the local office.

Trainer

Pre-Brief: Set up the simulation, evaluate and discuss trainee briefing and sectorizing for this event.

Simulation: Manage the simulation, pause the simulation and discuss important learning issues, and interject spotter reports.

Post-Brief: Discuss trainee performance, any lessons learned from the simulation, and how they can be implemented at the local office.

This interval-based simulation is designed to take 3.75 hours to complete, with 30 minutes for the pre-simulation briefing, 2.25 hours for the simulation, 30 minutes for simulation discussion, and 30 minutes for the post-brief. The simulation starts at 1645 UTC on June 29th, 1998 and ends at 1900 UTC on June 29th, 1998. As with all simulation examples, times can be adjusted as needed. The following sections are designed for the **trainer to use** to instruct and evaluate the trainee.

II.   Pre-simulation Briefing

The objective of the pre-simulation briefing is for the trainee to assess the level of threat for severe weather (tornado, hail, wind, and flash flooding), and formulate expectations of timing and evolution of convection. The trainer should step through the following tasks to prepare the simulation and evaluate/document the trainee performance:

Trainer Tasks

1. Print map with county names and CWA outline from Support Materials (see Figure C-C-2 on page C-3) for discussing warning sectors.

2. Print out the warning log from Support Materials (see page C-1) so the trainee can keep track of the warnings they issue.

3. Close down any existing D2D sessions, and start the simulator for the time period 1645 UTC on June 29th, 1998 to 1900 UTC on June 29th, 1998.

4. Stop the simulator immediately to allow the trainee to investigate the environment up to the start time.

5. Start a D2D session, and inform the trainee they have 30 minutes to analyze the environment of the DMX CWA and give a briefing to the trainer. If the trainee's local procedures have not been re-created on the WES, the trainer may wish to give the trainee more time to create procedures.

6. Instruct the trainee to:

   - Identify the level of threat for tornadoes, hail, wind, and flooding throughout the CWA,

   - In order to maximize the benefit of the different scenario types, we have focused this simulation on the northeast sector illustrated in Figure C-2 on page C-3. However, you may choose to ask the student about an optimal sectoring methodology,

   - Give a summary of the pre-simulation briefing analysis detailing the rationale behind the severe weather threats.

7. Briefly evaluate and discuss the reasoning behind the expected threat. In evaluating the trainee's briefing, consider the following issues:

   - 0-6 km shear 50 kts and BRN shear > 40 is supportive of supercell storms.

   - High anvil-level SR flow (70 kts) suggests classic supercells.

   - Low-level (0-3 km) shear remains weak (15-20 kts) limiting supercell tornado potential.

   - Midlevel SR flow for right-moving supercells is 30 kts which is favorable for tornadoes.

   - Morning sounding with steep lapse rates at OAX overlying rich surface dewpoints (mid 70°s). Mixed Layer CAPE (MLCAPE) is approximately 3500 j/kg with a modified temperature of 85° F and dewpoint of 75° F. The KOAX sounding is highly capped.

- Surface dewpoint depressions 15° F or less allow for favorably low LCLs for tornadoes assuming surface dewpoints are well mixed in the boundary layer.

- Steep mid-level lapse rates and dry air result in theta-E differences > 30° K from the surface to 700 mb. Wet microburst potential is high, especially with a well mixed boundary layer.

- Hail potential is high given steep mid-level lapse rates and 30 kt storm-relative midlevel flow. High Wet Bulb Zero (WBZ) values suggest some limitations to severe hail threat.

- Rapid initiation of multiple storms along a weak boundary in NW IA evidenced by explosive anvil growth and strong reflectivity cores in close proximity suggest potential for large cold pool development and outflow dominance.

- Short-duration, heavy rain potential heightened due to storms realizing the high CAPE. Rapid "Corfidi" vector motion will reduce prolonged heavy rain potential.

- There is no particular boundary except in the east-central part of Iowa. Airmass at 1600 UTC appears fairly homogeneous downstream of the initial storms.

- A localized area of pressure falls begins to develop centered over DSM from 1500 to 1800 UTC may support locally enhanced convergence and shear.

8. Make sure the trainee is comparing direct observations with the LAPS, or other diagnostic model output.

9. Inform the trainee that the flash flood guidance for the DMX CWA is approximately 2" for one hour, and 3" for three hours.

10. Point out on the SPC products provided in Appendix B that the CWA is in a moderate risk area, and a tornado watch has been issued with a threat for tornadoes, hail to 3 inches in diameter, and wind gusts to 75 kts.

III. Simulation

The training objectives of this interval-based simulation are to demonstrate effective methods of data interpretation, demonstrate proper type and content of warnings, and demonstrate how to weigh information and handle uncertainty in the warning decision making process. This simulation starts at 1645 UTC on June 29th, 1998 and ends at 1900 UTC on June 29th, 1998. At three times dur-

ing the simulation (1725, 1801, 1900 UTC; unknown to the trainee), the simulation will be paused and the trainer will assess the trainee's warnings and methodology. Discussion is encouraged. For a storm-by-storm breakdown of important features in the data and important evaluation points, consult the Trainer Evaluation Guide on page 2-7.

Trainer Tasks

1. Explain the objectives to the trainee (see page 2-1).

2. State to the trainee that:
   - There will be three pauses managed by the trainer, at surprise times, each lasting up to 10 minutes during the two hour simulation, at which times the trainer will query the trainee about their warnings and their methodology.
   - The trainee should communicate any problem areas to the trainer when there are potentially severe storms crossing out of or into the warning sector outlined in the pre-simulation briefing.
   - The trainer will be forwarding spotter reports to the trainee during the simulation.

3. Close down any existing D2D sessions, and start the simulation for the time period 1645 UTC on June 29th, 1998 to 1900 UTC on June 29th, 1998. Then start new D2D sessions. If only a single monitor exists, the trainer may wish to load two D2D sessions on one monitor to help mitigate the hardware limitation.

4. Show the trainee how to create a warning and save it to a file. To export a warning to a file after the warning has been typed up:
   - In the text editor, click under "File", "Export to File...".
   - Type in the name of the warning at the end of the path in the "filename" box on the bottom of the popup window and click OK.

5. Give the trainee 5-10 minutes to set up their D2D sessions.

6. During the simulation, provide storm reports as spotter reports. Use the reports listed in the Trainer Evaluation Guide (consult Appendix A for graphical locations).

7. At 1725 UTC pause the simulation for up to 10 minutes and ask:
   - (1) "What are the current warnings out and why?"
   - (2) "What is the expectation of these storms in the next 30 minutes?"

Get the trainee to focus on the reasoning behind the decisions and what products they are using to base their judgements. Discuss the reasoning with the trainee and try to reach a consensus on the warning decision. Some considerations for discussion points include:

- the level of threat for all severe weather types,
- product choice,
- warning composition details,
- radar sampling issues,
- environmental analysis, and
- uncertainty in the decision making process.

8. Resume Simulation.

9. At 1801 UTC pause the simulation for up to 10 minutes and repeat **Step 7**.

10. Resume Simulation.

11. At 1900 UTC pause the simulation for up to 10 minutes and repeat **Step 7**.

12. End the simulation after last pause, and give the trainee a 5 minute break.

IV. Post-simulation Briefing

The objectives of the post simulation briefing are to summarize the successes and failures of the warning process, and evaluate how this information can best be applied to local warning operations. The trainee should first be asked to give their perceptions of the simulation, and then should work with the trainer to evaluate performance and issues pertaining to the local warning operations. The trainer should use the evaluation completed during the pre-simulation briefing and simulation to focus discussion on relevant issues. Evaluation of performance should focus more on the reasoning behind the decision making than on how the warning products relate to the reports in Storm Data.

Some of the key issues to include in the discussion are:

- The importance of evaluating high-wind potential in thunderstorms prior to the arrival of high wind reports.
- The feasibility of discriminating tornadic and nontornadic tornado vortex signatures.

- The ability to calibrate radar products used to estimate hail size potential with real-time reports and modify previous expectations.
- The importance of evaluating data quality of the environment and radar data.

Trainer Tasks

1. Ask the trainee to:

    - Discuss the strengths and weaknesses of the data used in the decision making as well as the approach to analyzing the data.
    - Discuss any problems encountered with determining the type or content of the warnings.
    - Discuss the challenges of synthesizing the warning inputs and the sources of uncertainty.

2. Review the reports and the times to compare to the warnings.

3. Discuss the lessons learned from the event, and how best to implement changes at the local forecast office.

V.   Trainer Evaluation Guide

The training objectives of this interval-based simulation are to demonstrate effective methods of data interpretation, demonstrate proper type and content of warnings, and demonstrate how to weigh information and handle uncertainty in the warning decision making process. Part of the evaluation can be done during the query sessions in the simulation, and more evaluation can be done while the trainee is actively involved in the warning operations during the simulation. Suggestions for issues to evaluate while the trainee is creating products during the simulation are included below, as well as a storm-by-storm breakdown of important features in the data (including spotter reports) for the trainer to use during the simulation:

General Issues

Time (UTC)	Description
1603-1904 KDMX	radar data time period
1628-1910 KOAX	radar data time period
prior to 1701 KDMX	OHP data not available (This is an artifact of the process of developing this case.)
prior to 1706 KOAX	OHP data not available (This is an artifact of the process of developing this case.)
1827, 1844 KDMX	KDMX missing volume scans
1927-2311 KDVN	radar data time period

Considerations

- Does the trainee anticipate the general threat of severe weather to shift more to the southeast than the storm motion estimated from the mean 0-6 km wind or right-moving supercell motion? The multicell complex begins to move more southeast because of the large cold pool interacting with the lower-tropospheric inflow.

- Are radar precipitation estimates occasionally monitored for flooding threats even though it was not the primary severe weather expectation?

- Does the trainee use the radar algorithms as a safety net or as the primary warning tool? How do you think that affects the ability to detect severe weather threats and generate lead time in the warnings?

- Is the mesoscale environment data monitored at some time during the simulation (surface obs, VWP, and LAPS)?

- Does the trainee recognize the horizontal plot of LAPS helicity values are significantly too low, and they do not represent the actual 0-3 km storm relative helicity?

- Does the trainee recognize that LAPS spreads the gradient associated with the cold pool gust front too far from 1700-1900 UTC?

- Does the trainee recognize that the LAPS 850 mb winds are too low compared to the Slater, IA profiler at 1600-1700 UTC?

Storm Summary

During the simulation the convection in the northeastern warning sector experiences a consolidation eventually forming the northeastern part of a severe MCS. Even with the consolidated appearance of the storms in the low-level reflectivity product, the VIL product shows two main cells. The first cell develops at the beginning of this simulation (1647 UTC) in Calhoun County and moves ESE into Webster County before merging and dissipating into the general line. This storm develops supercell characteristics and requires monitoring immediately after the start of the simulation. A wind gust to 52 kt is reported in Rockwell City 1730 UTC in Calhoun County. While a one inch hail report is received 5 minutes later 5 miles southeast of Rockwell City, Calhoun County also experiences small stream flooding. Storm Total Precipitation (STP) shows a 2 - 2.5" maximum through the central part of Calhoun County and a 2.5-3" maximum along the Pocahontas-Calhoun County line. The STP values with the mid-county precipitation maximum may be slightly exaggerated due to hail.

The second area of interest begins as a merger of several cells in Webster and southern Humbolt counties. While there is no report for the first hour of the simulation, the TVS and mesocyclone algorithms trigger on numerous storm circulations from the beginning. The complex merger process requires careful storm structure examination to determine the significance of these circulations. The cluster of cells consolidates into one large cell with a single cold pool and a midlevel mesocyclone in the northern half of Hamilton County by 1721 UTC. Severe wind reports arrive at 1745 UTC near Blairsburg and 1750 UTC at Ellsworth in Hamilton County. The large area of high reflectivities also produces a widespread area of 2 - 2.5" rainfalls from southern pocahontas to southern Humbolt, Northern Webster, southern Wright and northern Hamilton and Hardin Counties. Urban and small stream flooding are reported well after the end of the simulation. Over the rest of the simulation, this storm continues to move east-southeast into Hardin, Grundy, Story, Marshall and then Tama counties. Numerous wind damage reports also arrive in these counties, however only a few arrive in real-time. An F1 tornado with a path length of one mile was reported well after the simulation was over, one mile east of Marshalltown in eastern Marshall County.

Calhoun-Webster County Storm

Time (UTC)	Description
1645 GOES-8	IR minimum cloud top temp -62°C
1647 KDMX	VIL increased to 65 kg/m2; POSH>70% MEHS = 1.75"; All reflectivity/VIL values use lower bound thresholds.
1652 KDMX	50 dBZ to 37 kft; POSH>70&% MEHS = 2" KOAX MEHS = 1.25"; All heights are considered Above Radar Level (ARL).
1701 KDMX	65 dBZ 17 kft; small WER on southeast flank
1702 GOES-8	IR minimum cloud top temp -65°C
1706 KDMX	50 dBZ to 40 kft; VIL 60 kg/m^2; MEHS = 2"
1711 KDMX	stronger WER; 35 kt rotational Velocity (V_r) lowest tilt only.
1715 GOES-8	IR minimum cloud top temp -68° C; Expansion of overshooting top. Three degree drop in the last 15 minutes is significant for an embedded overshoot.
1716 KDMX	Meso & TVS algorithm hits, V_r = 45-50kt at 10.5 kft; 65 dBZ to 32 kft; 55 dBZ to 44 kft; VIL >70 kg/m^2;
1721 KDMX	TVS & Meso algorithm hits; Meso strongest at 11 kft ARL; manual TVS observed lowest tilt just left of rear-inflow notch and right of core. First volume to detect this TVS and meso; VIL > 70 kg/m^2
1726 KDMX	No TVS from TDA; Meso still detected, Manual V_r = 50 kt at 11 kft; TVS still present but unbalanced; RFD surged southeast with deep convergence; 65 dBZ to 34 kft
1730	DMX LSR #1 tstm wind 52 kt Rockwell City (Calhoun County)
1731 KDMX	TVS no longer apparent; 2 mesos detected by algorithm; V_r = 45 kt at 11 kft; VIL down to 65 kg/m^2; 65 dBZ down to 24 kft
1732 GOES-8	IR minimum cloud temp -66°C
1735	DMX LSR #2 1" hail 5E Rockwell City (Calhoun County)
1736 KDMX	Meso detected by algorithm and manually, V_r = 45 kt 13 kft, circulation divergent at lowest slice; VIL > 70 kg/m$^{2;}$ 55 dBZ to 37 kft; MEHS = 1.75"
1741 KDMX	Several algorithm meso detections around horseshoe shaped RFD; Meso weaker and no circulation at 0.5°; Depth of convergence decreasing in the vicinity of the RFD; VIL > 70 kg/m^2; 55 dBZ to 40 kft; MEHS = 2"

Time (UTC)	Description
1745 GOES-8	Losing the IR cloud top minima to storms further west.
1746 KDMX	Elevated meso continues; V_r = 37 kt at 7.5 kft; No surface reflection; 55-60 dBZ to 24 kft; VIL down to 60 kg/m^2.
1746 KDMX	Multiple meso detections in central Webster County appear to be associated with small, shallow updrafts.
1751 KDMX	Multiple meso detections, all are elevated and are poorly organized; 55 dBZ to 24 kft; VIL down to 45 kg/m^2; MEHS down to 1"
1756 KDMX	Cell weakens and loses identity with respect to adjacent developing cells.

Considerations

- Is the trainee detecting the development of a Weak Echo Region (WER) for diagnosing the large hail threat in the Calhoun County storm at 1711?

- Does the trainee look for strong elevated reflectivity cores (e.g., 55-60 dBZ > 30 kft) to infer a large hail threat in Calhoun County from 1706 - 1716 UTC?

- Does the trainee note the drop in LTGCG frequency just as a strong elevated core and rotation develop from 1705 - 1710 UTC? A possible hypothesis is that the sudden updraft intensification elevated the charging mechanisms away from ground.

- Does the trainee use the mesocyclone and TDA product detections as the primary tool for considering storm rotation or is the base data investigated?

- Does the trainee consider issuing a tornado warning from 1715 to 1726 UTC for the Calhoun County storm?

- Does the trainee note the depth and strength of the rear-flank downdraft right of the mesocyclone at 1726 and consider a severe wind threat?

- After the 1735 hail report, does the trainee relate the observation to the data (e.g., depth of high reflectivities, VIL, the hail algorithm's MEHS)?

- What does the trainee believe the maximum hail size to be from this storm?

- Does the trainee discount the multiple mesocyclone circulations in Central Webster County at 1746 UTC?

- Does the trainee use severe weather statements to include the latest relevant information (e.g. reports of very large hail, high winds, etc.)?

- Does the trainee recognize the decrease in high reflectivities above 30 kft at 1746 and after?

- Does the trainee recognize that the LAPS 850 mb wind fields are underestimated up to 1800 UTC when compared to the Slater, IA profiler?

Pocahontas-Webster cell

Time (UTC)	Description
1642 KDMX	VIL = 65 kg/m^2; 55 dBZ top to 33 kft; MEHS = 1.25"; convergence 14-28 kft ARL, divergence 39 - 55 kft ARL; no other velocity signatures.
1645 GOES-8	IR cloud top temp cooled from -56° to -66°C in the last 15 minutes. Surrounding anvil top at -54°C.
1647 KDMX	VIL unchanged; 55 dBZ top to 26 kft; velocity range folded
1701 KDMX	VIL down to 55 kg/m^2; 55-60 dBZ top down to 18 kft
1702 GOES-8	IR cloud top temp min warmed to -62°C. Surrounding anvil cooled to -57° C. Other cloud top temp minima southeast.
1706 KDMX	VIL collapsed to 45 kg/m^2

Considerations

- Does the trainee notice the strength of this storm amongst the other adjacent small cells?

- Are hail sizes and wind speeds included in the warning, if a warning is issued?

- Does the trainee foresee that the storm inflow will quickly be cutoff because of the growing convection to its south and east?

Northern Webster-Wright-Hamilton-Hardin-Story-Marshall-Tama multicell cluster

Time (UTC)	Description
1701 KDMX	VIL increasing to 50- kg/m^2,55 dBZ to 20.3 kft. MEHS = 1"
1702 GOES 8	IR cloud top temp -62° C; Surrounding anvil at -57° C.

Time (UTC)	Description
1706 KDMX	TVS detected by TDA. Suspicious shape of high inbound velocities suggest dealiasing failure caused detection; 55 dBZ to 20.7 kft at 347° 53 nm; new cell southeast 55 dBZ to 17 kft at 344° 43 nm; lowest slice convergence at 346° 50 nm; VIL increased to 60 kg/m^2 for northern cell.
1711 KDMX	Weak low-level circulation; VIL decreased to 45 kg/m^2 for cell at 348° 52 nm and increased to 45 kg/m^2 for the cell at 350°/43 nm; 55 dBZ to 30 kft for southern cell; Core is elevated; MEHS still at 0.75".
1716 KDMX	Elevated 65-70 dBZ core 16-21 kft with southern cell at 352°/43 nm; VIL up to 65 kg/m^2; MEHS up to 2.25"; Northern storm 55 dBZ fell below 20 kft; VIL unchanged; Elevated meso for northern storm.
1715 GOES-8	IR cloud top temp -63°C over southern Humboldt County; Surrounding anvil at -59°C. No distinctive overshoot.
1721 KDMX	Northern cell lost identity; southern Cell 55 dBZ to 42 kft; elevated 65 dBZ 8 - 13 kft; VIL up to > 70 kg/m^2; MEHS = 2.25"; Numerous elevated meso detections, all with poor symmetry.
1731 KDMX	55 dBZ down to 31 kft; No more elevated core; VIL down slightly to ~65 kg/m^2; MEHS = 1.5"; >50kt SRM inbound velocities in lowest tilt on west side; 50 kt inbound velocity at 3 kft west Hamilton County
1732 GOES 8	IR cloud top temp -65°C over northern Webster County; Surrounding anvil cooled to -60°C.
1736 KDMX	Elevated mesocyclone develops NE Hamilton County; deep convergence SW of meso; 3 kft inbound velocities weaken to 36-50kt but remain coherent.
1741 KDMX	Elevated mesocyclone strengthens in NW Hardin CO.; deep convergence SW of meso; inbound velocities 50 kt central Hamilton County at 3 kft; VIL remains ~60 kg/m^2 but appears to be in two cores, northeast core associated with meso.
1745	DMX LSR #5 reported wind to 65 kt 2 miles South of Blairsburg (Hamilton CO)
1746 KDMX	>64 kt inbound velocities at 2.8 kft develop in E Hamilton County Large elevated mesocyclone moves east into Hardin County; Core appears to bow aloft toward mesocyclone center.; intense shear in SRM up to 6 kft SW of meso.

Time (UTC)	Description
1745 GOES 8	IR cloud top temp -66°C in multiple spots southern Wright County. Surrounding anvil -60°C. Overshoot is a broad dome.
1750	DMX LSR #6 reported wind to 65 kt Ellsworth (Hamilton County).
1751 KDMX	50 kt inbound velocities increase in coverage; TVS forms LLDV = 60 kt SW Hardin County at 2.5 kft; Deep inbound velocities northwest of TVS; Southwest updraft core with VIL = 65 kg/m^2 just NW of TVS.
1754	DMX LSR #8 wind to 56 kt 2 mi SW of Williams (Hamilton County).
1801 KDMX	Lost TDAs TVS detection in SW cell (SW Hardin Co); New TVS detected by TDA Central Hardin County; TVS not symmetrical but in apex of two gust fronts; New elevated core over and SE of new TVS with large WER; 55 dBZ to 27 kft; VIL down to 55 kg/m^2.
1806 KDMX	TVS and meso still detected by radar in East Hardin County; Meso strengthened aloft. 55 dBZ to 31 kft; VIL unchanged. MEHS = 1.75"; 50 kt inbound velocities spreading into Story County
1811 KDMX	Radar lost TVS; Long shallow shear from SE Hardin County to Story County; Broad elevated meso SE Hardin County, too broad for algorithm; 55 dBZ to 31 kft; VIL up to 60 kg/m^2; MEHS still 2".
1815	DMX LSR #19 Gust to 50kt Hubbard (Hardin County).
1816 KDMX	Meso detection by radar NW Marshall County suspect. Broad elevated meso SE Hardin too broad for 88D; 55 dBZ dropped to 29 kft; VIL down slightly 55 kg/m^2.
1815 GOES-8	GOES-IR cloud top temp -67°C; Surrounding anvil warmed to -59°C. Overshoot smaller and more focused
1821 KDMX	Elevated meso now in South Grundy Co; radar reidentified meso; TDA detection of TVS in S. Hardin County suspect at 0.5°; New elevated core in N. Marshall with WER; 55 dBZ to 30 kft.
1825	DMX LSR #21-22 Gust to 61 kt in Conrad (Grundy County). Another gust to 60 kt in Story (Story Co)

Time (UTC)	Description
1833 KDMX	Divergent elevated meso Tama, Marshall, Grundy County line; 88D mesos in Marshall County associated with numerous small updrafts; Maximum VIL down to 40 kg/m^2; 55 dBZ only to 20 kft;
1837	DMX LSR #25-27 Gusts to 57 kt in Marshalltown (Marshall County). Gust to 52 kt in Colorado (Story County).
1838 KDMX	Data only to 3.4°; Cosine effect artificially diminishing inbound velocities in Marshall County. Losing radial shear as a result.
1843	DMX LSR #29-30 Gust to 60 kt in Beaman (Grundy County). Gust to 56 kt in Gladbrook (Tama C.).
1846 GOES-8	GOES-8 IR cloud top temp -67°C. Surrounding anvil -55°C southeast of overshoot. Numerous overshoots to the west.
1848	DMX LSR #35-36 Gusts to 70 5 SW Marshalltown (Marshall County). Gusts to 56 kt Traer (Tama County).
1850 KDMX	Two TVSs detected by radar in central Tama County. 50 kts LLDV present at 065° 57 nm. TVSs under upper-level updraft. TVSs located near apex of gust front tracked since 1801 UTC. Low VIL < 30 kg/m^2.
1850	DMX LSR #43 Tornado 1E Marshalltown (Marshall County) delayed report by 1 hour. Time here is best estimated touch-down. (F1 assigned).
1856 KDMX	TVS continues Central Tama County. LLDV > 50kts at 5 kft. Cannot tell if TVS is undercut. Updrafts remain weak; VIL = 30 kg/m^2; Most outflow velocities below 0.5° slice and are tangential.
1901 KDMX	Lose data after 3.4°; Broad meso in Eastern Tama County.
1902 GOES-8	IR cloud top min -68°C in Northern Tama County. Strong over-shoot compared to -58°C anvil east. Broad -67°C overshoots west.

Considerations

- Does the trainee suspect the TDA detected in Northern Webster County at 1706 UTC might be illegitimate, possibly caused by dealiasing failures?

- Does the trainee recognize the elevated core with the intensifying cell in far eastern Webster County at 1711 UTC?

- Does the trainee recognize the large inbound velocities developing in NW Hamilton County by 1726 UTC. Has a severe thunderstorm warning been considered mentioning wind potential?

- Does the trainee recognize the deep, vertical convergence zone southwest of a large elevated mesocyclone located in Northeast Hamilton County at 1736 UTC?

- Does the trainee notice most of the LTGCG strikes occur northwest of the updraft containing the mid-level mesocyclone from 1730 - 1756 UTC?

- At 1746 UTC, inbound velocities are up to 64 kts at 4 kft ARL. Does the trainee mention expected winds in any warning that has been issued? Are expected hail sizes included too?

- How does the trainee react to the large shears observed in the lowest two velocity slices in far southeast Hamilton County at 1751 UTC?

- Does the trainee notice the multiple TVS detections by the radar in Hardin and Grundy Counties from 1751 to 1801 UTC? Does the trainee verify with base data if the TDA detection was noticed? Most of these are suspect.

- From 1801 to 1833 UTC, the maximum inbound velocities starting in southern Hardin County and ending in Tama County diminish over this period. Does the Trainee consider that as an artifact of viewing angle?

- Is the trainee monitoring the near storm environment with direct observations?

- For the 1800 UTC LAPS Surface-based CAPE (SBCAPE), does the trainee believe that the CAPE ranges from 3000 j/kg to as much as 6000 j/kg in the space of a couple counties ahead of the storms without any evidence of boundaries or other gradients?

- Between 1816 and 1830, the VILs, reflectivity values at high altitudes (~30 kft) and HDA algorithms all point to diminishing hail sizes. Since no hail reports were received with this storm, how does the trainee mention hail threat, even in the more intense updraft phase of this multicell?

- The radar data stops coming in from 1821 to 1833 UTC. Does the trainee notice?

- The radar stops again from 1838 - 1850 UTC. Does the trainee recognize the outage?

- In the absence of radar data, does the trainee consider using other data sources such as satellite and lightning to track storm motion and inten-

sity? Satellite cloud top temperatures are included for comparison from the more intense phase of the multicell to the lower topped phase.

- At 1856 UTC, another TVS is detected by radar in Tama County. This TVS is centered near a gust front apex that was tracked from southeast Hardin County. Does the trainee notice this signature is located under an elevated reflectivity core (20 kft) suggesting a locally stronger updraft?

- Does the trainee consider that this is an intense squall line in an environment moderately favorable for tornadoes and that strong and persistent signatures are less likely to precede tornadoes compared to more classical supercells?

- However, does the trainee also recognize that these high-level updrafts are not very strong, barely able to support > 45 dBZ cores at 25 kft and that no WERs or BWERs exist?

- Does the trainee recognize that high reflectivity cores above about 20 kft represent updrafts?

- Point this out to the trainee. Numerous elevated TVSs were detected by the TDA. These detections are not presently considered in the warning decision making process due to the lack of research evaluating their importance.

3: Situation Awareness Simulation

I. Introduction

This simulation focuses on the unique aspects of handling warning responsibility for a warning sector containing a storm that produces an extreme damaging wind event in a major metropolitan area. This simulation is appropriate for a warning forecaster with intermediate level of expertise who is proficient with the mechanics of issuing warnings. At three times, unknown to the trainee, the simulation will be paused for the trainer to evaluate the trainee's situation awareness.

Objective

The training objective of this situation awareness simulation is:

- Demonstrate the three levels of situation awareness (perceive, comprehend, project) during a challenging warning situation.

Responsibilities

Support materials in sections I (Introduction), II (Pre-simulation Briefing), III (Simulation), IV (Post-simulation Briefing), and V (Trainer Evaluation Guide) have been designed for a two person training session with the following responsibilities:

Trainee

Pre-Brief: Analyze the environmental data, issue a briefing detailing the threat for all severe weather types, and discuss sectorizing the county warning area.

Simulation: Issue warnings and follow up statements for the sector containing the storm that produces the extreme damaging wind event.

Post-Brief: Discuss with the trainer any lessons learned and how they can be implemented at the local office.

Trainer

Pre-Brief: Set up the simulation, evaluate and document trainee briefing and sectorizing for this event.

Simulation: Manage the simulation, pause the simulation to query the trainee's level of situation awareness, evaluate the performance of the trainee, and interject spotter reports.

Post-Brief: Discuss trainee performance and any lessons learned from the simulation and how they can be implemented at the local office.

This situation awareness simulation is designed to take 3.5 hours to complete, with 30 minutes for the pre-simulation briefing, 2.25 hours for the simulation, 30 minutes for querying, and 15 minutes for the post-brief. The simulation starts at 1700 UTC on June 29th, 1998 and ends at 1915 UTC on June 29th, 1998. As with all simulation examples, times can be adjusted as needed. The following sections are designed for the ***trainer to use*** to instruct and evaluate the trainee.

II.   Pre-simulation Briefing

The objective of the pre-simulation briefing is for the trainee to assess the level of threat for severe weather (tornado, hail, wind, and flash flooding), and formulate expectations of timing and evolution of convection. The trainer should step through the following tasks to prepare the simulation and evaluate/document the trainee performance:

Trainer Tasks

1. Print map with county names and CWA outline from Support Materials (see Figure C-C-2 on page C-3) for discussing warning sectors.

2. Print out the warning log from Support Materials (see page C-1) so the trainee can keep track of the warnings they issue.

3. Close down any existing D2D sessions, and start the simulator for the time period 1700 UTC on June 29th, 1998 to 1915 UTC on June 29th, 1998.

4. Stop the simulator immediately to allow the trainee to investigate the environment up to the start time.

5. Start a D2D session, and inform the trainee they have 30 minutes to analyze the environment of the DMX CWA and give a briefing to the trainer. If the trainee's local procedures have not been re-created on the WES, the trainer may wish to give the trainee more time to create procedures.

6. Instruct the trainee to:

   • Identify the level of threat for tornadoes, hail, wind, and flooding throughout the CWA.

   • In order to maximize the benefit of the different scenario types, we have focused this simulation on the southwest sector illustrated in Figure C-2 on page C-3. However, you may choose to ask the student about an optimal sectoring methodology.

   • Give a summary of the pre-simulation briefing analysis detailing the rationale behind the severe weather threats.

7. Briefly evaluate and discuss the reasoning behind the expected threat. In evaluating the trainee's briefing, consider the following issues:

   • 0-6 km shear 50 kts and BRN shear > 40 is supportive of supercell storms.

   • High anvil-level SR flow (70 kts) suggests classic supercells.

   • Low-level (0-3 km) shear remains weak (15-20 kts) limiting supercell tornado potential.

   • Midlevel SR flow for right-moving supercells is 30 kts which is favorable for tornadoes.

   • Morning sounding with steep lapse rates at OAX overlying rich surface dewpoints (mid 70s). Mixed Layer CAPE (MLCAPE) is approximately 3500 j/kg with a modified temperature of 85° F and dewpoint of 75° F. The KOAX sounding is highly capped.

   • Surface dewpoint depressions 15° F or less allow for favorably low LCLs for tornadoes assuming surface dewpoints are well mixed in the boundary layer.

   • Steep mid-level lapse rates and dry air result in theta-E differences > 30°K from the surface to 700 mb. Wet microburst potential is high, especially with a well mixed boundary layer.

   • Hail potential is high given steep mid-level lapse rates and 30 kt storm-relative midlevel flow. High Wet Bulb Zero (WBZ) values suggest some limitations to severe hail threat.

- Rapid initiation of multiple storms along a weak boundary in NW IA evidenced by explosive anvil growth and strong reflectivity cores in close proximity suggest potential for large cold pool development and outflow dominance.

- Short-duration, heavy rain potential heightened due to storms realizing the high CAPE. Rapid "Corfidi" vector motion will reduce prolonged heavy rain potential.

- There is no particular boundary except in the east-central part of Iowa. Airmass at 1600 UTC appears fairly homogeneous downstream of the initial storms.

- A localized area of pressure falls begins to develop centered over DSM from 1500 to 1800 UTC may support locally enhanced convergence and shear.

8. Make sure the trainee is comparing direct observations with the LAPS, or other diagnostic model output.

9. Inform the trainee that the flash flood guidance for the DMX CWA is approximately 2" for one hour, and 3" for three hours.

10. Point out on the SPC products provided in Appendix B that the CWA is in a moderate risk area, and a tornado watch has been issued with a threat for tornadoes, hail to 3 inches in diameter, and wind gusts to 75 kts.

III. Simulation

The training objective of this situation awareness simulation is to demonstrate three levels of situation awareness during a challenging warning situation. This 2 hour simulation starts at 1700 UTC on June 29th, 1998, and ends at 1915 UTC on June 29th, 1998. At three times during the simulation (1732, 1815, 1915 UTC; unknown to the trainee), the simulation will be paused and the trainer will assess the trainee's situation awareness by evaluating:

- Has the trainee perceived data relevant to all the severe weather threats (spotter reports, expiration times of current warnings, etc.)?

- Does the trainee understand the meaning of the data? (What warnings are needed?)

- Has the trainee formed an expectation based on these data? (Will the threat change over time?)

For a storm-by-storm breakdown of important features in the data and important evaluation points, consult the Trainer Evaluation Guide on page 3-8.

Trainer Tasks

1. State to the trainee that:

- The objectives of the simulation are to demonstrate the ability to perceive warning related inputs, understand the meaning of the assessment and project this into expectations and actions.

- There will be three pauses managed by the trainer, at surprise times, each lasting up to 10 minutes during the 2.25 hour simulation. At which times the trainer will ask.

  (1) "What is the current state of the severe potential and why?"

  (2) "What is the expectation of these storms in the next 30 minutes?"

  (3) "When will the current warnings expire?"

- The trainee should communicate any problem areas to the trainer when there are potentially severe storms crossing warning sectors.

- The trainer will be forwarding spotter reports to the trainee during the simulation.

2. Close down any existing D2D sessions, and start the simulation for the time period 1700 UTC on June 29th, 1998 to 1915 UTC on June 29th, 1998. Then start new D2D sessions. If only a single monitor exists, the trainer may wish to load two D2D sessions on one monitor to help mitigate the hardware limitation.

3. Show the trainee how to create a warning and save it to a file. To export a warning to a file after the warning has been typed up:

- In the text editor, click under "File", "Export to File...".

- Type in the name of the warning at the end of the path in the "filename" box on the bottom of the popup window and click OK.

4. Give the trainee 5-10 minutes to set up their D2D sessions.

5. During the simulation, provide storm reports as spotter reports. Use the reports listed in the Trainer Evaluation Guide on page 3-8 (consult image in Appendix A for graphical locations).

6. At 1732 UTC pause the simulation for up to 10 minutes and ask:

  (1) "What is the current state of the severe potential and why?"

(2) "What is the expectation of these storms in the next 30 minutes?"

(3) "When will the current warnings expire?"

- Try to get the trainee to focus on the reasoning behind the decisions and what products they are using to base their judgements. Document the reasoning, and take note of any significant severe weather cues not recognized. Pay particularly close attention to whether the trainee has identified the tornado threat for the storm in Monona/Crawford counties, the hail threat for the isolated storm in Carroll County, and the flooding threat in northwest Sac County.

- If the trainee is "lost" or behind, document the reason. If corrective measures are needed to "reengage" them, make adjustments before resuming.

7. Resume the simulation.

8. At 1815 pause the simulation and ask:

(1) "What is the current state of the severe potential and why?"

(2) "What is the expectation of these storms in the next 30 minutes?"

(3) "When will the current warnings expire?"

- Try to get the trainee to focus on the reasoning behind the decisions and what products they are using to base their judgements. Document the reasoning, and take note of any significant severe weather cues not recognized. Pay particularly close attention to whether the trainee has recognized the bow echo and supercell signatures in Boone/Greene Counties and the overall shift from isolated storms to linear storms.

- If the trainee is "lost" or behind, document the reason. If corrective measures are needed to "reengage" them, make adjustments before resuming.

9. Resume the simulation.

10. At 1915 pause the simulation and ask:

(1) "What is the current state of the severe potential and why?"

(2) "What is the expectation of these storms in the next 30 minutes?"

(3) "When will the current warnings expire?"

- Try to get the trainee to focus on the reasoning behind the decisions and what products they are using to base their judgements. Document the reasoning, and take note of any significant severe weather cues not recognized. Pay particularly close attention to whether the trainee has identified

the missing radar data and the extreme nature of wind threat with the Des Moines bow echo.

- If the trainee is "lost" or behind, document the reason. If corrective measures are needed to "reengage" them, make adjustments before resuming.

11. End the simulation, and give the trainee a 5 minute break.

IV. Post-simulation Briefing

The objective of the post simulation briefing is to summarize the successes and failures of the warning process and evaluate how this information can best be applied to local warning operations. The trainee should first be asked to give their perceptions of the simulation, and then should work with the trainer to evaluate performance and issues pertaining to the local warning operations. The trainer should use the evaluation done during the pre-simulation briefing and simulation to focus discussion on relevant issues. Evaluation of performance should focus more on the reasoning behind the decision making than on how the warning products relate to the reports in Storm Data.

Some of the key issues to include in the discussion are:

- Maintaining a high level of situation awareness throughout.
- Recognizing multiple severe weather threats with the storms.
- Recognizing early development of bow echo and supercell signatures.
- Understanding the significance of features relating to the development of extreme winds (e.g. elevated rear-inflow jet, supercell structure in the bow echo, deep convergence).
- Recognizing missing data and handling backup procedures.
- Maintaining the big picture issues while periodically focussing on the details.
- Communicating warning sector issues for the bow echo.

Trainer Tasks

1. Ask the trainee to:

- Discuss problems encountered with perceiving warning related inputs.

- Discuss any warning related inputs that were particularly challenging to understand.
- Discuss problems encountered with formulating expectations and actions.

2. Review the reports and the times to compare to the warnings.

3. Discuss the key issues of the event and any lessons learned, and how best to implement changes at the local forecast office.

V. Trainer Evaluation Guide

The training objective of this situation awareness simulation is for the trainee to demonstrate the three levels of situation awareness (perceive, comprehend, and project) during a challenging warning situation. Part of the evaluation can be done during the query sessions, and more evaluation can be done while the trainee is actively involved in the warning operations. Suggestions for issues to evaluate while the trainee is creating products during the simulation are included below, as well as a storm-by-storm breakdown of important features in the data (including spotter reports) for the trainer to use during the simulation:

General Issues

Time (UTC)	Description
1603-1904 KDMX	radar data time period
1628-1910 KOAX	radar data time period
prior to 1701 KDMX	OHP data not available (This is an artifact of the process of developing this case.)
prior to 1706 KOAX	OHP data not available (This is an artifact of the process of developing this case.)
1827, 1844 KDMX	KDMX missing volume scans
1927-2311 KDVN	radar data time period

Considerations:

- Does the trainee anticipate the general threat of severe weather to shift more to the southeast than the storm motion estimated from the mean 0-6 km wind or right-moving supercell motion? The multicell complex begins to move more southeast because of the large cold pool interacting with the lower-tropospheric inflow.

- Are radar precipitation estimates occasionally monitored for flooding threats even though it was not the primary severe weather expectation?

- Does the trainee use the radar algorithms as a safety net or as the primary warning tool? How do you think that affects the ability to detect severe weather threats and generate lead time in the warnings?

- Is the mesoscale environment data monitored at some time during the simulation (surface obs, VWP, and LAPS)?

- Does the trainee recognize the horizontal plot of LAPS helicity values are significantly too low, and they do not represent the actual 0-3 km storm relative helicity?

- Does the trainee recognize that LAPS is spreading the gradient associated with the cold pool gust front too far from 1700 - 1900 UTC?

- Does the trainee recognize that the LAPS 850 mb winds are too low compared to the Slater, IA profiler at 1600-1700 UTC?

Storm Summary

During the simulation there are at least five storm areas that require more detailed monitoring for severe weather in the warning sector that includes the west-central part of the CWA. The first area to monitor includes a cluster of storms in Woodbury, Cherokee, Ida, and Sac Counties. The storms produced dime and nickel sized hail outside the CWA, but no severe weather was reported as they moved into the CWA. Radar suggests there is a flooding threat and a slight hail and tornado threat with 2.5-3" one hour precip accumulation, 60 kg/m^2 VIL, and a weak TVS detection.

The second area to monitor contains an isolated storm in Carroll County that moves into Greene County. This storm has no severe weather reported with it, but it has indications of severe hail in the radar data.

The third area to monitor is the cluster of storms approaching Crawford county from Dakota, Woodbury, Thurston, Burt, and Monona Counties. Initially there are two supercell storms that merge, and a new cell forms and moves into Crawford County. The supercell storm in Dakota and Woodbury Counties (west of the CWA) produced dime sized hail and wind gusts to 52 kts before the simulation starts, though radar suggests larger hail was possible along with a tornado threat early in the storm's life. The supercell storm in Thurston County at the beginning of the simulation produces dime sized hail and a funnel cloud report, though it produced hail up to 2" and wind gusts to 70 kts earlier. As the two storms merge, a new cell develops along the leading edge of the high reflectivities in western Monona County around 1706 UTC and tracks into Crawford County. This cell rapidly intensifies and produces wind gusts to 65 kts, dime sized hail, and an F2 tornado, though radar suggests larger hail was possible.

The fourth area to monitor is the cluster of storms merging in Sac and Carrol Counties at 1715-1740 UTC that move into Greene County. These storms produce wind gusts of 69 kts. After producing the severe wind damage, the high wind observed by KDMX 1.5° base velocity product merges with the line segment in Greene and Boone Counties to help produce the extreme wind event in Des Moines.

The fifth area to monitor is the cluster of storms that merge in Greene County around 1750 UTC. The early development of the extreme wind event in Des Moines evolves from this conglomeration of cells around 1810 UTC. The area of strongest winds occurs with a supercell structure embedded within the bow echo. Widespread damaging winds occur with this bow echo with gusts to 104 kts as it moves through Des Moines. A series of tornadoes is reported with the area of rotation with most damage rated F1, though one tornado is rated with F2 damage. Urban and small stream flooding also occurs with the bow echo, and severe hail is not reported.

Woodbury-Cherokee-Ida-Sac County Storms (cluster of three storms)

Time (UTC)	Description
1622 KOAX	55 dBZ to 30 kft (N Woodbury County)
1628 KOAX	55 dBZ to 32 kft (NW Ida County)
1646 KOAX	55 dBZ to 30 kft (NE Woodbury County)

Time (UTC)	Description
1650	LSR FSD#2: 0.88" hail 3 NE Holsten (N Ida County)
1701 KOAX	NW Sac County 60 VIL, 1.5" MEHS
1701 KOAX	NW Ida County weak TVS (50 kt delta-V) with minimal to moderate rotational velocity (V_r 30 kts)
1705	LSR FSD#4: 0.75" hail 11 S Cherokee (S Cherokee County)
1716 KOAX	2.5-3" OHP (NW Sac County)

Considerations:

- Does the trainee consider utilizing the KOAX radar to interrogate the storms?
- If the trainee observes the TVS detection, is the base data reviewed to understand that the rotation is not strong and well organized?
- Does the trainee evaluate the heavy rainfall potential for this area?
- As the simulation progresses, is more time spent on evaluating other storms with more severe potential?

Carroll-Greene County Storm

Time (UTC)	Description
1706 KDMX	55 dBZ to 31 kft, MEHS 1.75"
1706 KOAX	55 dBZ to 30 kft
1711 KDMX	VIL 70 kg/m^2 (through1716), 65 dBZ to 30 kft
1711 KOAX	VIL 65 kg/m^2 (through 1721), 65 dBZ to 32 kft
1721 KOAX	65 dBZ 0.5° reflectivity
1736 KDMX	updraft intensify with 55 dBZ to 41 kft (> 30 kft through 1746)
1737 KOAX	55 dBZ to 37 kft (> 30 kft through 1747)
1757	storm merged into line

Considerations:

- Does the trainee isolate the hail threat as being the primary threat of severe weather with this storm?

- Does the trainee recognize the high reflectivity cores aloft in evaluating the hail threat?
- Does the trainee use the hail algorithm's maximum expected hail size in the warning or does the trainee make their own estimate from the base data analysis?

Dakota-Woodbury County Storm

Time (UTC)	Description
1632 GOES-8	IR cloud top min -64°C. Well formed overshoot.
1634 KOAX	VIL 70+ kg/m^2, moderate TVS (60 kt LL delta-V), strong rotation above 14 kft, 1.75" MEHS, 55 dBZ to 35 kft
1634-40 KOAX	bad velocity data on 1st trip
1648	LSR FSD#1: G52 4 SE Homer (SE Dakota County)
1650	LSR FSD#3: 0.75" hail in Lawton (N Woodbury County)
1656 KOAX	bad TVS detection on 1st trip bad data
1706 KOAX	storm merged into line

- Is the trainee aware that this storm is merging with the storm in Thurston County as it approaches the CWA?

Thurston-Monona County Storm

Time (UTC)	Description
1500	LSR OAX#1: 0.88" hail 6 S Verdel (Knox County)
1525	LSR OAX#2: G70 in Center, trees down and power outages (Knox County)
1545	LSR OAX#3: 2" hail 1 S Wasan (Knox County)
1602 GOES-8	IR cloud top temp min -67°C. 10°C cooler than anvil.
1620	LSR OAX#4: 1.75" hail in Carrol (Wayne County)
1625	LSR OAX#5: G65 in Wayne, wind damage across much of Wayne County
1628-1656 KOAX	VIL 70+ kg/m^2, 2-2.75" MEHS
1645	LSR OAX#6: G65 in Pender (SW Thurston)

Time (UTC)	Description
1651 KOAX	60 dBZ to 37 kft
1700	LSR OAX#7: funnel cloud 0.5 NW Lyons (Burt County)
1706 KOAX	mesocyclone undercut by outflow, reflectivity weakens aloft
1712	LSR OAX#8: 0.75" hail in Decatur (Burt County)

- Is the trainee aware that this storm is merging with the storm in Woodbury County as it approaches the CWA?

Monona-Crawford County Storm

Time (UTC)	Description
1706 KOAX	new cell in W Monona County (4-panel Z/SRM), low-level rotation organizing, moderate strength TVS begins (50-60 kt LL Delta-V, persists through 1732)
1711 KOAX	55 dBZ to 31 kft, moderate low-level rotation with HP supercell structure (W Monona County)
1715	LSR OAX#9: G65 kt 11 S Cherokee, trees and power lines down (Monona County)
1715 GOES-8	IR cloud top temp min -67°C. Large overshoot.
1715	LSR OAX#10: G65 4 SE Homer (through 1730), widespread trees damage, power lines down
1716 KOAX	55 dBZ to 38-42 kft (through 1727), 2-2.5" MEHS (through1727), VIL 65-70 kg/m^2 (through 1742)
1720	LSR OAX#11: G61 3 NE Holstein, Metal/wood cafe destroyed, metal grain bin destroyed, trees downed
1721 KOAX	circulation and gust front moving ESE at 50 kts
1727 KOAX	reflectivity inflow notch 0.5 Z/SRM
1730	LSR OAX#12: 0.75" hail Lawton
1732 GOES-8	IR cloud top temp min -70°C; 10°C cooler than anvil
1730	LSR OAX#13: G52 11 S Cherokee
1732 KOAX	Meso intensifying with strong rotation at 4 kft (0.5°), 50-64 kt ground-relative winds in occluded Meso
1752-1809	LSR DMX#7: F2 tornado 1 S Dow City to 11 E Dow City

Time (UTC)	Description
1800	LSR DMX#10: G50 in Manilla (SE Crawford County)
1800-2100	Urban/Small Stream Flood

Considerations:

- Is the trainee aware of the new cell development at 1706 associated with the merger of the Thurston and Woodbury County storms?
- Does the trainee recognize the organized rotation and TVS signatures with the storm?
- Does the trainee recognize the HP supercell structure?
- Does the trainee recognize the intensifying low-level rotation by 1732?
- Does the trainee consider issuing a tornado warning with additional wind and hail threats?
- Does the trainee prematurely cancel the warning when the radar observed signature weakens at 0.5°?
- Does the trainee use the closest radar (KOAX) to interrogate the storm?

Sac-Carroll-Greene County Storm (1715-1806)

Time (UTC)	Description
1736 KDMX	50-64 kt ground-relative winds at 7 kft (0.5 V) (SE Sac County)
1740	LSR DMX#3: G69 in Carroll (Carroll County)
1742 KDMX	50-64 kt ground-relative winds area increases (SE Sac County)
1745	LSR DMX#4: G57 in Glidden (Carroll County)

Considerations:

- Does the trainee recognize the 50-64 kt base velocities developing at 1736?
- Does the trainee isolate the damaging wind threat associated with this storm?

Greene-Boone-Dallas-Polk County Storm

Time (UTC)	Description
1751 KDMX	new core aloft (north central Greene County)
1806 KDMX	reflectivity intensifies aloft, moderate rotation above 8 kft above low-level rotation (W Boone County)
1810	LSR DMX#17: G69 Madrid (Boone County; note time not match radar)
1811 KDMX	55 dBZ to 34-38 kft (through 1821), VIL 60 kg/m2, 1.75" MEHS, 50-64 kt ground-relative velocities (SW Boone County), inflow acceleration ahead of line
1811	elevated rear inflow jet intensifying at 6 kft (1.5° V) on the back side of the line in E Greene County
1815	LSR DMX#18: G74 Perry (Dallas County)
1815 GOES-8	-72°C cloud top temp within -63°C anvil (through 1845 UTC)
1816 KDMX	deep convergence signature from 1-30 kft, convergent rotation in low-levels
1820-27	LSR DMX#20: F1 tornado 2.5 SE Berkley to 8.5 SE Berkley
1821 KDMX	strong rotation above 9 kft
1827 KDMX	radar data missing this volume scan
1827-41	LSR DMX#22: F1 tornado 10.5 NW Granger to Granger
1829	LSR DMX#24: G61 Madrid (Boone County)
1833 KDMX	tornado-scale shear in eye of occluded meso
1840	LSR DMX#28: G87 Granger (Dallas County; note time not match radar data)
1841-1903	LSR DMX#31: F2 tornado 5.5 N Grimes to 1 E Des Moines
1843-1846	LSR DMX#33: F1 tornado 2 NW De Soto to De Soto
1844 KDMX	radar data missing this volume scan
1846	LSR DMX#38: G61 Ankeny (Polk County)
1847	LSR DMX#39: G104 Johnston (Polk County)
1847	LSR DMX#40: G61 W Des Moines (Polk County)
1848	LSR DMX#41: G61 Urbandale (Polk County)
1849	LSR DMX#42: G69 Sailorville (Polk County)

Time (UTC)	Description
1850 KDMX	>64 kt winds at 0.5 kft (0.5° V) widespread in Polk County
1850	LSR DMX#44: G104 Des Moines (Polk County)
1854	LSR DMX#46: G55 Des Moines Airport (Polk County)
1855	LSR DMX#47: G61 Urbandale (Polk County)
1900-2100	Urban Small Stream Flood
1900	LSR DMX#52: G80 Altoona (Polk County)
1900	LSR DMX#53: G80 Des Moines
1900-2100	Urban Small Stream Flood
1903 KDMX	radar goes down for the day
1905	LSR DMX#59: G87 2 E Des Moines (Polk County)
1910	LSR DMX#60: Lightning damage 4 N Johnston
1910	LSR DMX#61: G56 Carlisle (Warren County)
1915	LSR DMX#64: G65 Hartford (Warren County)

Considerations:

- Is the trainee aware of the cell mergers and the new core aloft in north-central Greene County at 1751?

- Does the trainee evaluate the location and time of the 1810 report of strong winds in Madrid?

- Does the trainee recognize the development of an intense updraft at 1811 in western Boone County?

- Does the trainee recognize the development of the rear inflow jet around 6 kft at 1811?

- Does the trainee recognize the deep convergence signature at 1816 as being an indicator of a particularly strong updraft?

- Does the trainee recognize the supercell structure within the developing bow echo?

- Does the trainee recognize both the high wind threat and tornado threat?

- Does the trainee include wind reports in warnings or follow up severe weather statements?

- Does the trainee recognize the missing volume scans at 1827 and 1844?

- Does the trainee recognize that this is an extreme high wind event and communicate the threat properly in the statements?

- Does the trainee include wind estimates or expected damage in the warnings to motivate people to take shelter?

- Does the trainee follow appropriate backup procedures when finding out the radar is down?

- Does the trainee communicate issues of warning responsibility across warning sectors during the simulation?

4: Virtual Reality Simulation

I.   Introduction

This simulation focuses on the unique aspects of handling warning responsibility for a warning sector containing a storm that produces an extreme damaging wind event in a major metropolitan area. This simulation is appropriate for an experienced warning forecaster who is proficient with the mechanics of issuing warnings and can benefit from practicing warning workload management.

Objective

The training objective of this virtual reality simulation is to effectively manage all aspects of a challenging and distracting warning environment while still producing quality products.

Responsibilities

Support materials in sections I (Introduction), II (Pre-simulation Briefing), III (Simulation), IV (Trainer Evaluation Guide), and V (Post-simulation Briefing) have been designed for a two person training session with the following responsibilities:

Trainee

Pre-Brief: Analyze the environmental data, issue a briefing detailing the threat for all severe weather types, and discuss sectorizing the county warning area.

Simulation: Issue warnings and follow up statements for the sector containing the storm that produces the extreme damaging wind event.

Post-Brief: Discuss with the trainer any lessons learned and how they can be implemented at the local office.

Trainer

Pre-Brief: Set up the simulation, evaluate and document trainee briefing and sectorizing for this event.

Simulation: Manage the simulation, evaluate the performance of the trainee, and interject information such as spotter reports, special forecast requests, and any type of challenges that can happen in a real event (be creative!).

Post-Brief: Discuss trainee performance and any lessons learned from the simulation and how they can be implemented at the local office.

This virtual reality simulation is designed to take 3.5 hours to complete, with 30 minutes for the pre-simulation briefing, 2.5 hours for the simulation, and 30 minutes for the post-brief. The simulation starts at 1645 UTC on June 29th, 1998 and ends at 1915 UTC on June 29th, 1998. As with all simulation examples, times can be adjusted as needed. The following sections are designed for the *trainer to use* to instruct and evaluate the trainee.

II. Pre-simulation Briefing

The objective of the pre-simulation briefing is for the trainee to assess the level of threat for severe weather (tornado, hail, wind, and flash flooding), and formulate expectations of timing and evolution of convection. The trainer should step through the following tasks to prepare the simulation and evaluate/document the trainee performance:

Trainer Tasks

1. Print map with county names and CWA outline from Support Materials (see Figure C-C-2 on page C-3) for discussing warning sectors.

2. Print out the warning log from Support Materials (see page C-1) so the trainee can keep track of the warnings they issue.

3. Close down any existing D2D sessions, and start the simulator for the time period 1645 UTC on June 29th, 1998 to 1915 UTC on June 29th, 1998.

4. Stop the simulator immediately to allow the trainee to investigate the environment up to the start time.

5. Start a D2D session, and inform the trainee they have 30 minutes to analyze the environment of the DMX CWA and give a briefing to the trainer. If the trainee's local procedures have not been re-created on the WES, the trainer may wish to give the trainee more time to create procedures.

6. Instruct the trainee to:

- Identify the level of threat for tornadoes, hail, wind, and flooding throughout the CWA.

- In order to maximize the benefit of the different scenario types, we have focused this simulation on the southwest sector illustrated in Figure C-2 on page C-3. However, you may choose to ask the student about an optimal sectoring methodology.

- Give a summary of the pre-simulation briefing analysis detailing the rationale behind the severe weather threats.

7. Briefly evaluate and discuss the reasoning behind the expected threat. In evaluating the trainee's briefing, consider the following issues:

- 0-6 km shear 50 kts and BRN shear > 40 is supportive of supercell storms.

- High anvil-level SR flow (70 kts) suggests classic supercells.

- Low-level (0-3 km) shear remains weak (15-20 kts) limiting supercell tornado potential.

- Midlevel SR flow for right-moving supercells is 30 kts which is favorable for tornadoes.

- Morning sounding with steep lapse rates at OAX overlying rich surface dewpoints (mid 70s). Mixed Layer CAPE (MLCAPE) is approximately 3500 j/kg with a modified temperature of 85°F and dewpoint of 75°F. The KOAX sounding is highly capped.

- Surface dewpoint depressions 15°F or less allow for favorably low LCLs for tornadoes assuming surface dewpoints are well mixed in the boundary layer.

- Steep mid-level lapse rates and dry air result in theta-E differences > 30°K from the surface to 700 mb. Wet microburst potential is high, especially with a well mixed boundary layer.

- Hail potential is high given steep mid-level lapse rates and 30 kt storm-relative midlevel flow. High Wet Bulb Zero (WBZ) values suggest some limitations to severe hail threat.

- Rapid initiation of multiple storms along a weak boundary in NW IA evidenced by explosive anvil growth and strong reflectivity cores in close proximity suggest potential for large cold pool development and outflow dominance.

- Short-duration, heavy rain potential heightened due to storms realizing the high CAPE. Rapid "Corfidi" vector motion will reduce prolonged heavy rain potential.

- There is no particular boundary except in the east-central part of Iowa. Airmass at 1600 UTC appears fairly homogeneous downstream of the initial storms.

- A localized area of pressure falls begins to develop centered over DSM from 1500 to 1800 UTC may support locally enhanced convergence and shear.

8. Make sure the trainee is comparing direct observations with the LAPS, or other diagnostic model output.

9. Inform the trainee that the flash flood guidance for the DMX CWA is approximately 2" for one hour, and 3" for three hours.

10. Point out on the SPC products provided in Appendix B that the CWA is in a moderate risk area, and a tornado watch has been issued with a threat for tornadoes, hail to 3 inches diameter, and wind gusts to 75 kts.

III. Simulation

The training objective of this virtual reality simulation is to effectively manage all aspects of a challenging and distracting warning environment while still producing quality products. This 2.5 hour simulation starts at 1645 UTC on June 29th, 1998, and ends at 1915 UTC on June 29th, 1998. For a storm-by-storm breakdown of important features in the data and important evaluation points, consult the Trainer Evaluation Guide on page 4-7.

Trainer Tasks

1. State to the trainee:

- The training objective of this virtual reality simulation is to effectively manage all aspects of a challenging and distracting warning environment while still producing quality products.

- There will be no pauses during the 2.5 hour simulation (plan accordingly).

- The trainee should communicate any problem areas to the trainer when there are potentially severe storms crossing the warning sector selected in the pre-simulation briefing.

- The trainer will be forwarding spotter reports to the trainee during the simulation.

2. Close down any existing D2D sessions, and start the simulation for the time period 1645 UTC on June 29th, 1998 to 1915 UTC on June 29th, 1998. Then start new D2D sessions. If only a single monitor exists, the trainer may wish to load two D2D sessions on one monitor to help mitigate the hardware limitation.

3. Show the trainee how to create a warning and save it to a file. To export a warning to a file after the warning has been typed up:

- In the text editor, click under "File", "Export to File...".

- Type in the name of the warning at the end of the path in the "filename" box on the bottom of the popup window and click OK.

4. Give the trainee 5-10 minutes to set up their D2D sessions.

5. During the simulation, provide storm reports as spotter reports. Use the reports listed in the Trainer Evaluation Guide on page 4-7 (consult image in Appendix A for graphical locations), and make up conflicting spotter reports during the simulation to determine if the trainee is evaluating the reports well. Any other incoming calls or distractions should be interjected as to simulate a real environment. This could include briefings to EMS, toxic spills, failure for a warning to transmit, etc.

6. At 1701 UTC consider giving a distracting request. The Sac County emergency manager has called, wanting to know why there is no tornado warning. A TV station out of Omaha, NE is showing a NEXRAD Tornado Vortex Signature in northwest Ida County from their NIDS radar data. Evaluate the trainee's ability to effectively answer the request in a timely manner.

7. At 1715 UTC consider disrupting the warning operations. Inform the trainee that the last warning issued did not transmit properly. Evaluate the trainee's ability to recover from the disruption.

8. At 1730 UTC, consider giving a distracting request. The person writing the short term forecasts would like the trainee's input on the expected severe weather threat over central IA in the next 1-2 hours. Evaluate the trainee's ability to effectively answer the request in a timely manner.

9. At 1750 UTC consider disrupting the warning operations. Simulate a D2D crash or spontaneous logout. ***Do not stop the simulator.*** Either have the trainee exit and restart D2D, or have the trainee stop using D2D temporarily and explain how they would recover. Evaluate the trainee's ability to recover from the disruption.

10. At 1820 UTC consider giving a distracting request. A semi trailer containing hazardous materials has been involved in an accident on the east side of the Des Moines metro at the I-80 and I-35 interstate highway junction. The emergency response units would like a severe weather forecast relative to the accident site. The units are also interested in a wind forecast over the next few hours. Evaluate the trainee's ability to answer the request in a timely manner.

11. At 1840 UTC consider giving a distracting request. The Governor of Iowa is on the phone, calling from the global agriculture convention that has activities spread throughout the Des Moines metro. He has heard reports of tornadoes approaching the city, and he wants to know whether to advise all activities to prepare for the tornadoes. Evaluate the trainee's ability to clearly convey the tornado and high wind threat and answer the request in a timely manner.

12. At 1910 UTC inform the trainee that the radar was taken out by a lightning strike, and the office loses normal telecommunications to the outside world. Have the trainee step through the backup procedures, and evaluate whether proper procedures are followed. When finished, give the trainee a 5 minute break.

IV. Post-simulation Briefing

The objective of the post simulation briefing is to summarize the successes and failures of the warning process and evaluate how this information can best be applied to local warning operations. The trainee should first be asked to give their perceptions of the simulation, and then should work with the trainer to evaluate performance and issues pertaining to the local warning operations. The trainer should use the evaluation done during the pre-simulation briefing and simulation to focus discussion on relevant issues. Evaluation of performance should focus more on the reasoning behind the decision making than on how the warning products relate to the reports in Storm Data.

Some of the key issues to include in the discussion are:

- Handling stress and workload so as to keep the effective flow of information going.
- Off-loading tasks as necessary.
- Recognizing missing data and handling backup procedures.
- Maintaining the big picture issues while periodically focussing on the details.
- Maintaining a high level of situation awareness throughout.
- Recognizing multiple severe weather threats with the storms.
- Recognizing early development of bow echo and supercell signatures.
- Understanding the significance of features relating to the development of extreme winds (e.g. elevated rear-inflow jet, supercell structure in the bow echo, deep convergence).
- Communicating warning sector issues for the bow echo.

Trainer Tasks

1. Ask the trainee to:
   - Discuss challenges in managing the warning workload for the sector.
   - Discuss any problems encountered with responding to the disruptions in the warning environment.
2. Review the reports and the times to compare to the warnings.
3. Discuss the lessons learned from the event, and how best to implement changes at the local forecast office.

V. Trainer Evaluation Guide

The training objective of this virtual reality simulation is to effectively manage all aspects of a challenging and distracting warning environment while still producing quality products. The evaluation of the trainee by the trainer is to be done while the trainee is actively involved in the warning operations. Suggestions for issues to evaluate while the trainee is creating products during the simulation are included below, as well as a storm-by-storm breakdown of important features in the data (including spotter reports) for the trainer to use during the simulation.

General Issues

Time (UTC)	Description
1603-1904 KDMX	radar data time period
1628-1910 KOAX	radar data time period
prior to 1701 KDMX	OHP data not available (This is an artifact of the process of developing this case.)
prior to 1706 KOAX	OHP data not available (This is an artifact of the process of developing this case.)
1827, 1844 KDMX	KDMX missing volume scans
1927-2311 KDVN	radar data time period

Considerations:

- Does the trainee anticipate the general threat of severe weather to shift more to the southeast than the storm motion estimated from the mean 0-6 km wind or right-moving supercell motion? The multicell complex begins to move more southeast because of the large cold pool interacting with the lower-tropospheric inflow.

- Are radar precipitation estimates occasionally monitored for flooding threats even though it was not the primary severe weather expectation?

- Does the trainee use the radar algorithms as a safety net or as the primary warning tool? How do you think that affects the ability to detect severe weather threats and generate lead time in the warnings?

- Is the mesoscale environment data monitored at some time during the simulation (surface obs, VWP, and LAPS)?

- Does the trainee recognize the horizontal plot of LAPS helicity values are significantly too low, and they do not represent the actual 0-3 km storm relative helicity?

- Does the trainee recognize that LAPS is spreading the gradient associated with the cold pool gust front too far from 1700 - 1900 UTC?

- Does the trainee recognize that the LAPS 850 mb winds are too low compared to the Slater, IA profiler at 1600-1700 UTC?

Storm Summary

During the simulation there are at least five storm areas that require more detailed monitoring for severe weather in the warning sector that includes the west-central part of the CWA. The first area to monitor includes a cluster of storms in Woodbury, Cherokee, Ida, and Sac Counties. The storms produced dime and nickel sized hail outside the CWA, but no severe weather was reported as they moved into the CWA. Radar suggests there is a flooding threat and a slight hail and tornado threat with 2.5-3" one hour precip accumulation, 60 kg/m^2 VIL, and a weak TVS detection.

The second area to monitor contains an isolated storm in Carroll County that moves into Greene County. This storm has no severe weather reported with it, but it has indications of severe hail in the radar data.

The third area to monitor is the cluster of storms approaching Crawford county from Dakota, Woodbury, Thurston, Burt, and Monona Counties. Initially there are two supercell storms that merge, and a new cell forms and moves into Crawford County. The supercell storm in Dakota and Woodbury Counties (west of the CWA) produced dime sized hail and wind gusts to 52 kts before the simulation starts, though radar suggests larger hail was possible along with a tornado threat early in the storm's life. The supercell storm in Thurston County at the beginning of the simulation produces dime sized hail and a funnel cloud report, though it produced hail up to 2" and wind gusts to 70 kts earlier. As the two storms merge, a new cell develops along the leading edge of the high reflectivities in western Monona County around 1706 UTC and tracks into Crawford County. This cell rapidly intensifies and produces wind gusts to 65 kts, dime sized hail, and an F2 tornado, though radar suggests larger hail was possible.

The fourth area to monitor is the cluster of storms merging in Sac and Carrol Counties at 1715-1740 UTC that move into Greene County. These storms produce wind gusts of 69 kts. After producing the severe wind damage, the high wind observed by KDMX 1.5° base velocity product merges with the line segment in Greene and Boone Counties to help produce the extreme wind event in Des Moines.

The fifth area to monitor is the cluster of storms that merge in Greene County around 1750. The early development of the extreme wind event in Des Moines

evolves from this conglomeration of cells around 1810 UTC. The area of strongest winds occurs with a supercell structure embedded within the bow echo. Widespread damaging winds occur with this bow echo with gusts to 104 kts as it moves through Des Moines. A series of tornadoes is reported with the area of rotation with most damage rated F1, though one tornado is rated with F2 damage. Urban and small stream flooding also occurs with the bow echo, and severe hail is not reported.

Woodbury-Cherokee-Ida-Sac County Storms (cluster of three storms)

Time (UTC)	Description
1622 KOAX	55 dBZ to 30 kft (N Woodbury County)
1628 KOAX	55 dBZ to 32 kft (NW Ida County)
1646 KOAX	55 dBZ to 30 kft (NE Woodbury County)
1650	LSR FSD#2: 0.88" hail 3 NE Holsten (N Ida County)
1701 KOAX	NW Sac County 60 VIL, 1.5" MEHS
1701 KOAX	NW Ida County weak TVS (50 kt delta-V) with minimal to moderate rotational velocity (V_r 30 kts)
1705	LSR FSD#4: 0.75" hail 11 S Cherokee (S Cherokee County)
1716 KOAX	2.5-3" OHP (NW Sac County)

Considerations:

• Does the trainee consider utilizing the KOAX radar to interrogate the storms?

• If the trainee observes the TVS detection, is the base data reviewed to understand that the rotation is not strong and well organized?

• Does the trainee evaluate the heavy rainfall potential for this area?

• As the simulation progresses, is more time spent on evaluating other storms with more severe potential?

Carroll-Greene County Storm

Time (UTC)	Description
1706 KDMX	55 dBZ to 31 kft, MEHS 1.75"
1706 KOAX	55 dBZ to 30 kft

Time (UTC)	Description
1711 KDMX	VIL 70 kg/m^2 (through1716), 65 dBZ to 30 kft
1711 KOAX	VIL 65 kg/m^2 (through 1721), 65 dBZ to 32 kft
1721 KOAX	65 dBZ 0.5° reflectivity
1736 KDMX	updraft intensify with 55 dBZ to 41 kft (> 30 kft through 1746)
1737 KOAX	55 dBZ to 37 kft (> 30 kft through 1747)
1757	storm merged into line

Considerations:

• Does the trainee isolate the hail threat as being the primary threat of severe weather with this storm?

• Does the trainee recognize the high reflectivity cores aloft in evaluating the hail threat?

• Does the trainee use the hail algorithm's maximum expected hail size in the warning or does the trainee make their own estimate from the base data analysis?

Dakota-Woodbury County Storm

Time (UTC)	Description
1632 GOES-8	IR cloud top min -64°C. Well formed overshoot.
1634 KOAX	VIL 70+ kg/m^2, moderate TVS (60 kt LL delta-V), strong rotation above 14 kft, 1.75" MEHS, 55 dBZ to 35 kft
1634-40 KOAX	bad velocity data on 1st trip
1648	LSR FSD#1: G52 4 SE Homer (SE Dakota County)
1650	LSR FSD#3: 0.75" hail in Lawton (N Woodbury County)
1656 KOAX	bad TVS detection on 1st trip bad data
1706 KOAX	storm merged into line

• Is the trainee aware that this storm is merging with the storm in Thurston County as it approaches the CWA?

Thurston-Monona County Storm

Time (UTC)	Description
1500	LSR OAX#1: 0.88" hail 6 S Verdel (Knox County)
1525	LSR OAX#2: G70 in Center, trees down and power outages (Knox County)
1545	LSR OAX#3: 2" hail 1 S Wasan (Knox County)
1602 GOES-8	IR cloud top temp min -67°C. 10°C cooler than anvil.
1620	LSR OAX#4: 1.75" hail in Carrol (Wayne County)
1625	LSR OAX#5: G65 in Wayne, wind damage across much of Wayne County
1628-1656 KOAX	VIL 70+ kg/m^2, 2-2.75" MEHS
1645	LSR OAX#6: G65 in Pender (SW Thurston)
1651 KOAX	60 dBZ to 37 kft
1700	LSR OAX#7: funnel cloud 0.5 NW Lyons (BurtCounty)
1706 KOAX	mesocyclone undercut by outflow, reflectivity weakens aloft
1712	LSR OAX#8: 0.75" hail in Decatur (Burt County)

- Is the trainee aware that this storm is merging with the storm in Woodbury County as it approaches the CWA?

Monona-Crawford County Storm

Time (UTC)	Description
1706 KOAX	new cell in W Monona County (4-panel Z/SRM), low-level rotation organizing, moderate strength TVS begins (50-60 kt LL Delta-V, persists through 1732)
1711 KOAX	55 dBZ to 31 kft, moderate low-level rotation with HP supercell structure (W Monona County)
1715	LSR OAX#9: G65 kt 11 S Cherokee, trees and power lines down (Monona County)
1715 GOES-8	IR cloud top temp min -67°C. Large overshoot.
1715	LSR OAX#10: G65 4 SE Homer (through 1730), widespread trees damage, power lines down

Time (UTC)	Description
1716 KOAX	55 dBZ to 38-42 kft (through 1727), 2-2.5" MEHS (through1727), VIL 65-70 kg/m^2 (through 1742)
1720	LSR OAX#11: G61 3 NE Holstein, Metal/wood cafe destroyed, metal grain bin destroyed, trees downed
1721 KOAX	circulation and gust front moving ESE at 50 kts
1727 KOAX	reflectivity inflow notch 0.5 Z/SRM
1730	LSR OAX#12: 0.75" hail Lawton
1732 GOES-8	IR cloud top temp min -70°C; 10°C cooler than anvil
1730	LSR OAX#13: G52 11 S Cherokee
1732 KOAX	Meso intensifying with strong rotation at 4 kft (0.5°), 50-64 kt ground-relative winds in occluded Meso
1752-1809	LSR DMX#7: F2 tornado 1 S Dow City to 11 E Dow City
1800	LSR DMX#10: G50 in Manilla (SE Crawford County)
1800-2100	Urban/Small Stream Flood

Considerations:

- Is the trainee aware of the new cell development at 1706 associated with the merger of the Thurston and Woodbury County storms?

- Does the trainee recognize the organized rotation and TVS signatures with the storm?

- Does the trainee recognize the HP supercell structure?

- Does the trainee recognize the intensifying low-level rotation by 1732?

- Does the trainee consider issuing a tornado warning with additional wind and hail threats?

- Does the trainee prematurely cancel the warning when the radar observed signature weakens at 0.5°?

- Does the trainee use the closest radar (KOAX) to interrogate the storm?

Sac-Carroll-Greene County Storm (1715-1806)

Time (UTC)	Description
1736 KDMX	50-64 kt ground-relative winds at 7 kft (0.5 V) (SE Sac County)

Time (UTC)	Description
1740	LSR DMX#3: G69 in Carroll (Carroll County)
1742 KDMX	50-64 kt ground-relative winds area increases (SE Sac County)
1745	LSR DMX#4: G57 in Glidden (Carroll County)

Considerations:

- Does the trainee recognize the 50-64 kt base velocities developing at 1736?

- Does the trainee isolate the damaging wind threat associated with this storm?

Greene-Boone-Dallas-Polk County Storm

Time (UTC)	Description
1751 KDMX	new core aloft (northcentral Greene County)
1806 KDMX	reflectivity intensifies aloft, moderate rotation above 8 kft above low-level rotation (W Boone County)
1810	LSR DMX#17: G69 Madrid (Boone County; note time not match radar)
1811 KDMX	55 dBZ to 34-38 kft (through 1821), VIL 60 kg/m2, 1.75" MEHS, 50-64 kt ground-relative velocities (SW Boone County), inflow acceleration ahead of line
1811	elevated rear inflow jet intensifying at 6 kft (1.5° V) on the back side of the line in E Greene County
1815	LSR DMX#18: G74 Perry (Dallas County)
1815 GOES-8	-72°C cloud top temp within -63°C anvil (through 1845 UTC)
1816 KDMX	deep convergence signature from 1-30 kft, convergent rotation in low-levels
1820-27	LSR DMX#20: F1 tornado 2.5 SE Berkley to 8.5 SE Berkley
1821 KDMX	strong rotation above 9 kft
1827 KDMX	radar data missing this volume scan
1827-41	LSR DMX#22: F1 tornado 10.5 NW Granger to Granger
1829	LSR DMX#24: G61 Madrid (Boone County)
1833 KDMX	tornado-scale shear in eye of occluded meso

Time (UTC)	Description
1840	LSR DMX#28: G87 Granger (Dallas County; note time not match radar data)
1841-1903	LSR DMX#31: F2 tornado 5.5 N Grimes to 1 E Des Moines
1843-1846	LSR DMX#33: F1 tornado 2 NW De Soto to De Soto
1844 KDMX	radar data missing this volume scan
1846	LSR DMX#38: G61 Ankeny (Polk County)
1847	LSR DMX#39: G104 Johnston (Polk County)
1847	LSR DMX#40: G61 W Des Moines (Polk County)
1848	LSR DMX#41: G61 Urbandale (Polk County)
1849	LSR DMX#42: G69 Sailorville (Polk County)
1850 KDMX	>64 kt winds at 0.5 kft (0.5° V) widespread in Polk County
1850	LSR DMX#44: G104 Des Moines (Polk County)
1854	LSR DMX#46: G55 Des Moines Airport (Polk County)
1855	LSR DMX#47: G61 Urbandale (Polk County)
1900-2100	Urban Small Stream Flood
1900	LSR DMX#52: G80 Altoona (Polk County)
1900	LSR DMX#53: G80 Des Moines
1900-2100	Urban Small Stream Flood
1903 KDMX	radar goes down for the day
1905	LSR DMX#59: G87 2 E Des Moines (Polk County)
1910	Lightning damage 4 N Johnston
1910	LSR DMX#61: G56 Carlisle (Warren County)
1915	LSR DMX#64: G65 Hartford (Warren County)

Considerations:

- Is the trainee aware of the cell mergers and the new core aloft in north-central Greene County at 1751?

- Does the trainee evaluate the location and time of the 1810 report of strong winds in Madrid?

- Does the trainee recognize the development of an intense updraft at 1811 UTC in western Boone County?

- Does the trainee recognize the development of the rear inflow jet around 6 kft at 1811 UTC?

- Does the trainee recognize the deep convergence signature at 1816 as being an indicator of a particularly strong updraft?

- Does the trainee recognize the supercell structure within the developing bow echo?

- Does the trainee recognize both the high wind threat and tornado threat?

- Does the trainee include wind reports in warnings or follow up severe weather statements?

- Does the trainee recognize the missing volume scans at 1827 and 1844?

- Does the trainee recognize that this is an extreme high wind event and communicate the threat properly in the statements?

- Does the trainee include wind estimates or expected damage in the warnings to motivate people to take shelter?

- Does the trainee follow appropriate backup procedures when finding out the radar is down?

- Does the trainee communicate issues of warning responsibility across warning sectors during the simulation?

5: Case Study Simulation

I.   Introduction

In this exercise, D2D will be used to review data which covers a 4 hour period from 1200 UTC to 1645 UTC on June 29th, 1998. Climatology, synoptic-scale processes, then mesoscale processes will be considered sequentially to provide a multi-scale analysis related to the warning process. Following this analysis, the trainee may wish to proceed on to any of the warning simulation examples included with the Simulation Guide. This exercise is appropriate for a forecaster who can benefit from multi-scale analysis.

Objectives

The training objectives of this case study simulation are to:

- To provide a learning aid for operational meteorologists in analyzing and assessing the pre-storm convective storm environment. In this case study simulation mode, the goal of the analysis process is the development of a Hazardous   Weather   Outlook   (HWO: http://www.srh.noaa.gov/jan/hwo_info.htm). The particular HWO product for this case study simulation is intended to describe a 0 to 12 hr forecast of expected severe weather across the County Warning Area (CWA), which, for this simulation, is Des Moines, IA (DMX).

- After the analysis process, the trainee is expected to answer a short series of questions to help evaluate understanding of some of the concepts that are exemplified in the forecast process described in the guide. By completing these training activities, the trainee can improve skill levels in analyzing and assessing the pre-storm convective environment. Using this simulation guide can also help prepare the trainee to improve performance during other simulation modes.

The local training officer may wish to run through the case study in its current form, or use this example to create their own case study with different learning objectives.

Responsibilities

Support materials in sections I (Introduction), II (Environment Analysis), and III (Evaluation Process) have been designed for a two person training session with the following responsibilities:

Trainee

- The trainee will be asked to incorporate a forecast funnel approach (similar to steps outlined in the Severe Convection Professional Development Series - currently under development) in order to analyze and synthesize the data from 1200 to 1600 UTC on 29 June 1998 into a forecast of expected severe weather for the next 12 hours. In particular, the approach will mirror the job task skills in PCU 3 and 4 (synoptic and mesoscale assessment). The trainee should first analyze the synoptic scale environment, from the 1200 UTC upper air data and the 1200-1300 UTC METAR data and make a forecast of the relative likelihood of general severe weather based on that assessment. Then, the trainee should proceed with a mesoscale analysis from 1300 to 1600 UTC to modify (if needed) and further specify the expectations of the perceived severe weather threat. The perceived severe weather threat will be expressed in the text of the HWO.

Trainer

- Review of the HWO text will allow the trainer a way to gauge how well the trainee can synthesize the data and formulate into a forecast product. Since forecasting is a highly subjective process, evaluation of how well the trainee analyzes the environment on the synoptic scale and mesoscale is difficult. However, the practicing of a prescribed methodology based on certain job task skills defined in the severe convection PDS may help forecasters, especially novice ones, to develop and hone certain skills that are important in performing this stage of the integrated warning process. For a means of objective evaluation, the trainer will have a series of questions to present to the trainee on particular aspects of the event and the forecast process employed that should be answered at the conclusion of the simulation. Evaluating the trainee's answers to these questions will provide an excellent opportunity to review some important conceptual understanding of severe weather evolution and possibly offer the trainee some further training options (teletraining, web sites, etc.). Upon completion of this simulation, the trainer may wish to have the

trainee proceed to one of the other simulation types in this WES simulation guide.

This case study simulation is designed to take 3.5 hours to complete. As with all simulation examples, times can be adjusted as needed. The following sections are designed for the **trainer to use** to instruct and evaluate the trainee.

II.   Environmental Analysis

Climatology (optional)

The suggested completion time for the Climatology section is 20 minutes.

The objective of the climatology analysis is to become familiar with the relative frequency of severe weather on June 29th for the DMX CWA. NSSL's online severe weather climatology module will be used as the analysis tool to evaluate severe weather climatology. This module uses the Storm Data database and the Tom Grazulis Tornado Project database to create heavily smoothed time and space plots of severe weather frequency in the continental US. Details of the analysis techniques are included with the online module that is loaded in this section. The trainee and trainer will need to use a PC connected to the internet to work through the exercise. This web-based climatology analysis can be easily applied to other CWA's, and it can be incorporated into any existing local climatology.

Trainer Tasks

1. On a PC connected to the internet, have the trainee analyze the following website:

<p align="center">http://www.nssl.noaa.gov/hazard/</p>

2. Ask the trainee to analyze how the calendar date June 29th relates to the average severe weather season for tornadoes, hail, and wind. To do this task, have the trainee generate a time series for each severe event type for the DMX CWA by selecting the annual cycles button and then for the appropriate event type, click on the middle of Des Moine's CWA.

3. Evaluate whether the trainee determined the following climatological information for June 29th:

- this day of the year is relatively close to the peak season for tornadoes, and past the peak for significant tornadoes.

- this day is slightly past the peak date for large hail probabilities.

- this day is in the middle of the severe wind probabilities peak.

- This day lies near the peak of the season for significant severe wind events (> 65 kt).

4. Ask the trainee to click on the "animations" button on the top of the page to begin to analyze the magnitude of the severe weather probabilities relative to surrounding areas. State that the goal of the next exercise is for the trainee to determine:

- whether the probabilities are a local maximum/minimum in the region.

- how the probability relates to the peak probabilities nationally.

5. Under the "All Severe Weather" table have the trainee analyze the three animations (tornado, severe hail, and severe wind) for the 1980-1999 time period. After the loop has loaded, instruct the trainee to stop the loop and page through to find closest image to June 29.

6. Under the "High End Severe Weather" table have the trainee analyze the four animations (F2+ 1921-1995, F4+ 1921-1995, 2"+ hail, and 65+ kt wind). After the loop has loaded, instruct the trainee to stop the image and page through the loop to find the closest image to June 29.

7. Ask the trainee to summarize the analysis of how the local probabilities relate regionally and nationally.

8. Evaluate whether the trainee determined the following:

- probabilities for tornadoes peak at 1 - 1.5% within 25 miles of any point in central IA in early June. Iowa is in an east-west axis of higher probabilities which starts in Northeast Colorado.

- Probabilities for severe wind (>50 kt) shows little change between Iowa and adjacent areas.

- However, there is an axis of maximum probabilities for significant severe wind (>65 kt) running through central Iowa.

- Probabilities for large hail peak at 3% earlier in June.

9. Discuss the role of climatology in the warning process with the trainee and the limitations of climatological databases. Recognition of severe weather threats relative to climatology can be used to attain better situation awareness if used appropriately. Be sure to point out that:

- Just because climatology suggests a higher or lower probability for a particular severe weather type doesn't mean that it will or won't occur on any given day.

- The databases contain many errors and limitations given the relatively short time period and reporting issues.

Synoptic Assessment (from the Severe Convection PDS)

The suggested completion time for the Synoptic Assessment section is 1 hour and 40 minutes.

The objectives of the synoptic assessment are:

- To analyze the environment to determine if current (or future) large scale processes and patterns are favorable for severe convection. By incorporating a four-dimensional analysis of the data at this scale, one can determine the potential for subsequent severe weather development and achieve an understanding of the physical processes.

- Compare your current synoptic analysis to a synoptic climatology. Use your knowledge of environmental climatological patterns in your region to recognize potential heightened threats associated with the patterns and associated parameters. See http://www.nwstc.noaa.gov/METEOR/CWD/SvrClimo.HTML for a reference on the application of climatology to severe storm forecasting).

- Evaluate model forecasts of synoptic-scale features for the period up to 0000 UTC June 30th.

- Relate the evaluation to severe weather threat.

(Period analyzed is 1200-1300 UTC)

Trainer Tasks - Set Up

1. Close down any existing D2D sessions, and start the simulator for the time period 1630 UTC on June 29th, 1998 to 1700 UTC on June 29th, 1998. Doing so will prevent any of the data after the analysis period from being visible.

2. Stop the simulator immediately to allow the trainee to investigate the environment up to the start time

3. Set the start time on the D2D display to 1230 UTC June 29th, 1998. To do this:

    • Click with the left mouse on the "Time:" display on the bottom right-hand part of the D2D window.

    • Enter the year, date, and time after clicking on "Set Time".

    • Click "OK".

4. Copy any procedures from the real-time AWIPS over to the WES machine.

KSA 1. Analyze surface and upper air data.

(KSA stands for Knowledge, Skills and Abilities. KSAs are specific job task skills in a Professional Competency Unit (PCU). The PCUs and KSAs will be part of the Convective PDS training format soon to be announced.)

Look for the presence of salient features such as shortwave troughs, thermal troughs, low-level thermal/moisture axes, mid-level dry intrusions, upper- and lower-level jet streaks, and static stability.

Upper air data from 1200 UTC 29 June 98

250 mb analysis summary:

Note that observations indicate a broad, anticyclonically curved jet extended from the central CA coast across the Northern Plains (eastern SD/southern MN) to the northern mid-Atlantic coast. The strongest band of winds in the core of the jet was located from eastern SD through southern MN (120 kts). The 250 mb winds turned sharply southeastward south of the main jet which was creating a zone of diffluence across northeastern Kansas into northern Missouri.

500 mb analysis summary:

Note that the low was centered just north of the MN/ON border with sharp cyclonic shear axis extending westward across US/CN border. A weak trough axis extended southward from the low through MN/western IA into northeast KS. Cold air advection was noted on the H5 analysis with cyclonic flow pattern across much of northern MO/IA and the southern half of MN in association with the shortwave trough. A belt of very strong winds at 500 mb was observed

across eastern SD (75 kts at KABR) to southern MN into WI. The axis of 50 kts west-northwesterly winds extended as far south as KOAX.

700 mb analysis summary:

Overall pattern depicts a low center in southwestern Ontario, a weak downstream shortwave located across WI and another weaker shortwave trough embedded in the broad cyclonic flow from the eastern Dakotas to central NE. Strong cold air advection noted spreading east-southeastward across the Dakotas into portions of the Upper MS River Valley. Very warm air (T> 12°C) aloft noted around the periphery of a high pressure centered across the southern Plains. Moist air at H7 level (T_d depressions < 4° C) possibly due to preexisting convection was noted across MO/IL. Drier air intrusion at H7 level was suggested in the analysis across western SD possibly extending as far south as western KS.

850 mb analysis summary:

Pattern at 1200 UTC suggests a low pressure center in west central SD with a frontal boundary extending eastward across northern IA. Winds south of the boundary were southerly (15 kts at KOAX) and northwesterly north of the boundary across SD and MN. A thermal ridge extended northeastward across the Central Plains into central IA with H85 temps > 24°C at KOAX. The moist axis (H85 dew-points > 22°C) also extended northeastward into southwestern IA.

KSA 2. Analyze regional RAOBs.

Analyze the soundings in order to assess buoyancy, vertical wind shear, and other convective parameters.

1. Ask the trainee to load the KOAX and KDVN 1200 UTC soundings to analyze important wind, temperature, and moisture variability over the region.

2. Discuss the summary with the trainee.

1200 UTC KOAX Skew-T analysis summary:

Deep moisture is present through almost the lowest kilometer, then sharp drying above with a 22°C T_d depression max at 850 mb (5200 ft AGL). Very steep

lapse rates close to dry adiabatic are noted from the 830 mb level to approximately 530 mb. Winds are southerly through the first 2 km then veer sharply to west northwesterly and increase in speed to 55kts at 500 mb (18,2 kft). Winds stay westerly at 50-70kts to the tropopause level (122 mb). Derived thermodynamic parameters such as CAPE based on a surface forecast max temp (100/66) lift yield a value of 3110 J/kg.

Note to WES trainers: The source of the "forecast max temp" in AWIPS is **not** the same as "anticipated" max temps. It is computed based on a combination of three variables: 1) the climatolological monthly max/min temp, 2) relative humidity and cloud cover in the sounding, and 3) the total amount of energy available for heating and the sounding temperature profile. There are known limitations for using this technique. See http://meted.ucar.edu/awips/validate/index.htm.

A more realistic CAPE based on anticipated max temps /dew-points along and south of the warm front (84/76) yields approximately 5120 J/kg and a Lifted Index of -12°C. There is a moderate amount of CIN (-78 J/kg) below the LFC when this parcel is lifted. In addition to the large CAPE, steep lapse rates, and very high EL (46.5 kft) suggest a large hail potential, perhaps limited by high wet-bulb zero heights (13 kft ASL). Midlevel cold advection later in the day may increase the large hail threat. Surface to midlevel Theta-E differences exceed 30°K, in combination with large wetbulb temperature differences, could result in strong evaporative cooling in organized downdrafts that develop. Thus, damaging winds are a threat. The vertical shear profile at KOAX suggest supercells are possible. The 0-3 km SRH (based on 30R75) is only 137 m^2/s^2 with faster moving storms (306°/28 kts) increasing the SRH only slightly (to around 150 m^2/s^2) suggesting a limited tornado threat. Very rich low-level moisture may lead to high instantaneous rainfall rates, but quite strong unidirectional middle and upper level flow may diminish a large flash flooding threat.

1200 UTC KDVN Skew-T analysis summary:

This sounding was not as unstable (Lifted Index based on a forecast MAX temp lift is -8°C, CAPE = 2653 j/kg) as 1200 UTC KOAX sounding due to lack of steep lapse rates, but the KDVN sounding is certainly supportive of strong convection. Practically no CIN is suggested using a MAX temp lift. Lots of dry air in midlevels similar to western IA. However, not as much southerly flow at low levels as KOAX but very strong westerly winds at midlevels (50-75 kts) from 6 to 10

km. The shape of the hodograph and SRH (98 m^2/s^2) limits the tornado threat more than what the Skew-T at Omaha suggests.

KSA 3. Use compositing techniques.

As a part of the diagnostic forecast process, use compositing techniques to superimpose salient synoptic scale features and assess any particular juxtaposition of the features for the purpose of recognizing the pattern and associated severe weather type.

Summary of 1200 UTC compositing techniques:

The location of synoptic scale features, especially the strong westerly mid and upper level winds north of a east-west frontal boundary (central IA) is similar in some respects to the warm season progressive derecho pattern (Also, see http://www.nwstc.noaa.gov/METEOR/SynPat/synpat_main_frm.htm for a good description of this pattern.) There will be a question on this pattern in the evaluation section.

KSA 4. Using a knowledge of severe convective patterns and known model biases, perform an integrated 4-D analysis of future (or expected) synoptic parameters to evaluate the large-scale threat of severe convection in your CWA in the next 12 hours.

a. Evaluate changes in convective potential using numerical model data.

b. Determine expected (or forecast) sounding/hodograph parameters based on modifying the sounding using gridded model data.

1. Ask the trainee to load the 4-panel ETA family on a regional scale for the 1200 UTC output.

Summary of 4-panel ETA family on regional scale: (analyze the 1200 UTC ETA model output)

Upper left panel shows upper level forcing from H5 short wave trough and associated vorticity lobe initially from northern MN to western ND is forecast to pivot around the upper low into Lake Superior region by 1800 UTC. Secondary vort max initialized at 1200 UTC across eastern MT is forecast to track rapidly into eastern IA by 1800 UTC and central IN by 0000 UTC on 30 Jun 98. The ETA

also shows a H7 short wave trough moving into southern MN, western IA, northern MO by 1800 UTC. Associated 1000-500 mb layer relative humidities indicate increasing deep moisture ahead of this trough. Biggest 0-12 hr signal in the 4-panel progs are in the precip fields. The ETA depicts a large 700 mb mega maximum initially over central SD/eastern NE at 1200 UTC to move southeastward to northern MO/western IL by 1800 UTC and into southern IL/IN by 00 UTC. Just to the northwest of the upward motion maximum area, a large circular-shaped Omega minimum area is indicated in the models to develop by 1800 UTC from eastern NE through IA and central WI. The model generates a large area of > 0.25 inches of 6 hr convective precipitation (0.36 inch max) over central and northwest IA in the Omega minimum area.   In addition, at the surface the ETA develops a weak surface high over eastern IA by 1800 UTC

2. Ask the trainee to either clear or use a new display. Ask the trainee to load these ETA parameters:

   • 0 - 6 km bulk shear from the Convective menu within the Volume Browser

   • 850 mb winds

   • 0 - 3 km bulk shear from the Convective menu within the Volume Browser

   • "Corfidi" vectors from the Convective menu within the Volume Browser

   • Right-moving supercell motion from the Convective menu within the Volume Browser

Summary of Shear and propagation parameters

Other interesting fields noted from the 120 UTC ETA model forecast were 0-6 km bulk shear. At 1200 UTC there was 35 kts across the southern half of the CWA to 50 kts in the north. By 1800 UTC, the shear was expected to increase to 50 kts or greater over the entire CWA (the exception was the extreme southern half of the CWA). By 0000 UTC, the 0-6 km bulk shear was forecast to increase to 65 kts over the entire CWA. Most of this shear increase was due to changes in the speed of the 500 mb winds (45-50 kts at 1200 UTC to ~ 70 kts by 0000 UTC. The 850 mb winds were progged to become more westerly and increase to around 20 kts by 0000 UTC on 30 Jun 98. The 0-3 km bulk shear, initially 10 to 15 kts, was forecast to increase to 30 to 35 kts by 1800 UTC, and 30 kts at 0000 UTC. Thus, convection that was expected to develop would have an increasingly strong downshear propagation component. "Corfidi" vectors also suggested that convective complexes would have a east southeasterly movement from 20 to 40 kts across the CWA during this time period. In terms of

supercell motion, the ETA forecast a right moving storm motion of 20 kts from the NW increasing to 30-35 kts from 1800 to 0000 UTC.

3. Ask the trainee now to load these parameters from the Volume Browser.

- 0 - 3 km Storm Relative Helicity (SRH)
- 500 mb Storm Relative Flow

Summary of SRH and Storm-Relative flow

The SRH (0-3 km) off the ETA was depicting max contoured values from around 210-240 m2/s2 to develop by 1800 UTC in a north to southwest corridor across the DMX CWA. By 0000 UTC these values dropped off to < 60 m^2/s^2 as winds became strongly unidirectional. Midlevel (500 mb) Storm-Relative (SR) flow magnitude was forecast to remain in the 25-35 kts range through 1800 UTC, then expected to increase to around 40 kts over the eastern part of the CWA by 0000 UTC. Overnight, midlevel SR flow remained in the 35-40 kt range.

4. Ask the trainee to erase or bring up a blank display and then to load these parameters from the Volume Browser:

- Surface theta-E
- Surface-Based CAPE (SBCAPE)

Summary of Buoyancy parameters

Large negative vertical gradients in theta-e (20-23°C gradients) at 1200 UTC across most of IA decreasing to 15°C gradients by 1800 UTC indicated high potential convective instability and enhanced the potential for development of strong downdrafts. All layered moisture and thermal model fields showed a significant feedback from the convective precipitation generated over northern and central IA between 1200 and 1800 UTC. Model horizontal CAPE fields (surface based) show a very sharp N-S gradient (800 j/kg in the north to 3000 j/kg in the south) across the CWA which suggest that a large convective event is forecast by the ETA to evolve over the DMX CWA for the next 0-6 hours.

5. Ask the trainee to add these parameters from the Volume Browser:

- Bulk Richardson Number (BRN)
- Energy Helicity Index (EHI)

Summary of BRN and EHI parameters

BRN forecasts, initially 25 over the CWA, was forecast to increase to > 100 over the eastern half of IA by 1800 UTC as CAPE sharply increased ahead of the model forecast convective complex. Cooling and diminished CAPE values associated with the "passage" of the forecast convective complex reduced BRN values to around 15-35 by 0000 UTC.

Energy Helicity Index (EHI) values suggested a slight increase from 0.5 to around 1.25 across central IA by 1800 UTC but a much stronger signal was indicated across NE into northeastern KS into northern MO.

Note: For a discussion of some important environmental parameters for forecasting severe weather type, see pages 16-29 (Lesson 3) of the WDTB DLOC training student guide on Convective Storm Structure and Evolution. (This document is available on the WDTB website at http://wdtb.noaa.gov.)

6. Ask the trainee to bring up a clear window or erase everything on the present display. Then begin to load the ETA model soundings for:

   - A point near DMX,

   - A point in Sac County,

   - A point in Mahaska County,

   - and a point in Cass County.

Summary of ETA forecast soundings:

Four points at various quadrants of the CWA were analyzed in order to glean any details in the vertical profiles at specific locations. The point over central IA (near DMX) indicated deep moistening of the profile by 1800 UTC and low-level passage of a "convective complex" as winds became northwesterly in the lowest 1 km AGL. By 0000 UTC, winds had become southwesterly again with significant drying in low levels and aloft. Overnight (0600 - 1200 UTC), winds were forecast to become northwesterly and dry out in low- to midlevels as midlevel cold trough was forecast to occur to move through.

Further NW, the forecast sounding exhibited greater drying through the profile by 1800 UTC but maintained a south wind at the surface. CAPE was forecast to be around 2000 j/kg with a SRH of around 186 m^2/s^2.

In the SE quadrant, the sounding shows the effects of the model "convective complex signal" by 1800 UTC with strong northwesterly winds and near saturated profile in the lowest 2 km AGL.

The forecast point in the SW quadrant of the CWA also shows the low level passage of a boundary (could be induced by a outflow or squall line) with a northerly wind shift by 1800 UTC. The sounding stays quite unstable with a Lifted Index to -12°C and CAPE > 4500 j/kg at 0000 UTC. Overnight, the forecast sounding shows increasingly stable profile and diminished low-level convergence.

Note to trainers and trainees: The use of model soundings, especially the ETA, are most valuable up until the time the model initiates convection (in this case, by 1800 UTC). Thus, after the model convection has developed, use objective analysis fields from the nearby unmodified atmosphere.

KSA 5. Know how to utilize remote sensing data to augment model initial conditions.

1. Ask the trainee to bring up a clear display and load the GOES-IR and VIS loops. Overlay the 5 minute lightning data.

Summary of analysis of satellite and other remote sensing data at 1200-1300 UTC.

1215 - 1302 UTC IR and visible satellite imagery indicated a large forward propagating mesoscale convective complex moving east southeastward across eastern MO/IL. Upstream, some convection was beginning to increase over southeastern SD into southwestern MN due to enhanced upward motion from low-level convergence, warm advection and an approaching H5 shortwave trough. Five minute lightning plots also verified the increase in convective activity in southeastern SD/southwestern MN and even a small cluster of thunderstorm activity in extreme northwest IA along an outflow boundary analyzed previously.

KSA 6.   Forecast general type of severe weather based on evaluation of patterns and parameter values.

1. Have the trainee draft a Hazardous Weather Outlook (HWO) describing the threats of severe weather expected in the Des Moines CWA for the day end-

ing on 0000 UTC June 30th, 1998. The trainee should address a relative threat (slight, moderate, high) for each of these elements:

- severe wind,
- large hail,
- flash flooding,
- and tornadoes.

Summary of synoptic analysis relating to the 1300 UTC HWO:

Based on analysis of the current data including the synoptic environmental pattern, plus the ETA model forecast signals, there appears to be a moderate chance of a significant severe threat across the CWA during the morning and afternoon of the 29th. Very high CAPE values with little cap and strong mid-level winds suggest potential for damaging winds threat. Also, supercells with large hail are possible given the strength of the 0-6 km shear. Low-level SRH and EHI from ETA forecast profiles suggest tornadic development a slight possibility. Flash flooding not considered a significant threat due to fast forward propagation of storms.

More analysis is required from real-time data and higher resolution model output to help specify the threat and the potential impact areas in the CWA. The next analysis time will be starting at 1625 UTC.

Mesoscale Analysis (from the Severe Convection PDS)

(Period of analysis is 14-1600 UTC)

Trainer Tasks - Set Up

1. Set the time on the D2D display to 1625 UTC June 29th, 1998. To do this:
    - Click with the left mouse on the "Time:" display on the bottom right-hand part of the D2D window.
    - Enter the year, date, and time after clicking on "Set Time".
    - Click "OK".

KSA 1. Determine buoyancy and shear-related characteristics of the mesoscale environment for the purpose of anticipating potential convective storm types through the use of model output, in-situ and remote-sensing observational data.

KSA 2. Apply conceptual models of cloud microphysics, convective mesoscale processes, and storm life cycles, for the purpose of identifying convective storm types and associated hazardous weather threats in the 0-6 hr. time frame.

KSA 3. Evaluate convective initiation aspects in your CWA (i.e., potential timing and location).

KSA 4. Modify (if needed) your expectation of general severe weather threat from the synoptic analysis based on your Mesoscale assessment.

1. In order to address KSAs 1-4, have the trainee load a GOES-8 Visible loop for 12 frames on a clear display.

   - Load the 5 minute cloud-to-ground lightning.
   - Load the METAR surface observations and make sure density is set high enough to plot most stations.
   - Load the surface LAPS SBCAPE

From 1400 to 1600 UTC, based on remote sensing observations (satellite and lightning), a tremendous increase in convective development has occurred across the southeastern SD/northeastern NE/northwestern IA region. Some of the largest increases in convective intensity based on increases in lighting frequency and cloud top growth have occurred across Knox and Cedar counties in extreme northeast NE, across Clay and Union counties in southeastern SD, and Sioux and Plymouth counties in northwest IA. The developing storm complex is moving rapidly southeastward into northwestern IA, where, due to strong surface heating processes (see surface observations at KSLB and KLRJ), surface based CAPE (based on the 1500 UTC LAPS) values are now in the 4400 to 4800 J/kg range. Note that these values are considerably higher than was forecast by the 1200 UTC ETA. LAPS CAPE values from 3000-4000 J/kg also extended across central IA by 1600 UTC, which was much higher than the ETA had forecast.

2. Now have the trainee load the LAPS MSL pressure and 3 hour pressure ten-
    dencies.

The outflow boundary has now pushed into northcentral IA with a well defined
meso high center analyzed near KEST. The warm front initially over southcen-
tral IA at 1300 UTC, is more difficult to analyze from 1500 to 1600 UTC, but
southerly winds were beginning to become more prevalent south of the outflow
boundary across portions of central and western IA. A meso low was analyzed
by the LAPS (and verified by analysis of 1600 UTC METAR data) near KOMA
with 3-hr pressure falls of 3- 4 mb indicated across portions of west central IA.

3. On a clear display in state or WFO scale, have the trainee call up a Profiler
    sounding in the Volume Browser using the "RUC + Profiler" as the field, for a
    point near DMX at 1600 UTC. Have the trainee evaluate the accuracy of the
    LAPS wind profile.

Vertical wind profiles based on profiler data (SLAI4) in central IA indicate much
stronger shear below 3 km than what was analyzed by LAPS sounding data
from 1400 to 1600 UTC. The 0-3 km SRH is approximately twice that of the
LAPS sounding (SRH = 128 m^2/s^2). The stronger low-level flow combined with
increasingly faster forward speed of the developing convective complex
increased system-relative flow (especially at low levels). This physical concept
has been observed to be well correlated to the longevities of Mesoscale Con-
vective Systems (MCS) such as derechos. Increasing low-level convergence
into the outflow boundary resulting from the large pressure falls, was also
enhancing development of new cells along the downshear side of the convec-
tive complex. If this process continued, it would enhance downshear propaga-
tion affects.

4. Have the trainee evaluate how the LAPS 1600 UTC SBCAPE with the same
    sounding compares to that of the ETA for 1800 UTC in the same area.
    *   It is not necesary for the trainee to load the ETA sounding unless he/she
        needs to be reminded of the ETA forecasts.
    *   Buoyancy profiles off LAPS suggested greater values of CAPE, with no
        CIN, than the ETA predicted.

5. Now have the trainee load the LAPS "Corfidi" vectors on a state or WFO maps with lightning as an overlay. Ask the trainee to estimate the arrival time of the developing complex in Des Moines.

Propagation of the convective complex was definitely in the downshear direction thus the ETA forecast Corfidi vector movement was likely underestimating the speed of the system. Overall system movement over the last 2 hours suggested the complex would impact the DMX CWA within the next hour. (Note to trainers: Additional training for trainees on propagation and evolution of convective storms is available on pages 31-82 in Lesson 4 of Convective Storm Structure and Evolution DLOC Student Guide. Also, see the COMET CD-ROM *An MCS Matrix: Squall Lines and Bow Echoes*, available on the web at http://meted.comet.ucar.edu/convectn/mcs/index.htm.)

6. Have the trainee draft an updated Hazardous Weather Outlook (HWO) using WarnGen. The HWO should describe the threats of severe weather expected in the Des Moines CWA for the day ending on 0700 UTC June 30th, 1998. The trainee should mention how the threat for severe weather has changed since the 1310 UTC HWO for the following:

   • severe wind,
   • large hail,
   • flash flooding,
   • tornadoes,
   • and, the trainee should be able to provide an estimate of where the thunderstorms will be over the next few hours for the larger population centers in the CWA.

Resulting forecast:

Severe potential in the CWA was likely greater than previously anticipated due to changes in the mesoscale environment during the 1400 - 1600 UTC period. Main convective mode based on sounding parameters and on 1600 radar reflectivity mosaic is likely to be supercells. There is an additional possibility of isolated tornadoes based on increasing low level shear (and increased SRH)

profiles in central IA. Radar and satellite observations show numerous storms developing in close proximity to each other suggesting the potential development of an MCS with embedded supercells and a strong cold pool. Due to the observations of new cells rapidly developing on the downshear side of the cluster, propagation effects will likely cause the convective system to move faster than the mean flow of the cloud layer.

A HWO mentioning the threat from damaging winds, large hail and possible tornadoes over CWA during the next 2-3 hours would be a good forecast based on analysis of the data. Initial expectations based on model data suggest that the convective event may move across the entire CWA by 0000 UTC. The flash flooding threat appears to still be problematic at this point due to the fast forward movement of this developing complex. However, initial radar data did indicate very strong reflectivity cores of 55-60 dBZ over portions of NW IA at 1600 UTC, so brief flooding in low-lying areas is certainly a possibility.

III. Evaluation Process

The following are a series of questions that can be used by the trainer to help evaluate the trainee's understanding of the event and help improve the trainee's skill levels for PCUs 3 and 4 (Analyzing and Assessing the Synoptic and Mesoscale Environment).

1. Based on analysis of the 1200-1300 UTC surface and upper air data for this event, what similarities are there to the warm season derecho pattern described in http://www.nwstc.noaa.gov/METEOR/SynPat/synpat_main_frm.htm? What particular features are distinctly different?

Answer: Middle and upper level winds are similar, but surface features are somewhat different. The low-level jet is well displaced from initial convective activity for this case. No well-defined elongated east-west frontal boundary is present. High surface dew-points in derecho genesis and mid-point areas.

2. What particular limitations exist in the 1200 upper air and 1300 UTC surface data set to effectively analyze synoptic scale features?

Answer: No raob at LBF. Lack of METARS in NW IA mesonet. This lack of surface data becomes a significance problem during 1700-2000 UTC as convective complex approaches the CWA.

3. What piece of data was critical prior to 1600 UTC in helping to diagnose potential storm types and impacts of the organizing convective complex?

Answer: Slater, IA profiler which shows much stronger low level flow ahead of the multicell complex. Also, could mention LAPS CAPE data which shows much stronger buoyancy and system updraft strength.

4. Did the ETA depict the timing of the convective complex accurately?

Answer: Probably had a good signal but timing was too fast.

5. How does system relative flow affect the intensity of convective systems?

Answer: For a system with strong storm relative shear (due to faster forward speeds), SR flow increases low-level convergence on the downshear side of the system, increases updraft development in the downshear location, maintains an erect updraft along the leading edge, and ultimately increases MCS longevity. Numerical modeling suggests that an elevated Rear-Inflow Jet is necessary to re-balance cold pool and shear effects (See pages 56-59 of the Convective Storm Structure and Evolution DLOC Student Guide for more explanation of the propagation and evolution of multicell convective complexes).

6. How does propagation affect movement of MCSs?

Answer: Movement of MCSs (and multicell systems in general, are a result of many processes which ultimately affect the summative influences of advection and propagation. If the propagation component of an MCS is acting in the downshear direction (and sufficient instability exists in the downshear direction), then the propagation will be much stronger than the mean cloud bearing layer. In this event, propagation was likely causing the system to move much faster than the mean wind. Damaging wind threats from linear MCS are greatest in forward-propagating systems, whereas, in backward-propagating MCSs, heavy rain is the predominate threat.

Appendix A: Storm Reports

I.   DMX CWA Reports

Rpt #	Location	Time (UTC)	Storm Characteristic
1	**Calhoun County**		
	Rockwell City	1730	**Thunderstorm Wind (G 52)**
2	**Calhoun County**		
	5 E Rockwell City	1735	**Hail (1.00)**
3	**Carroll County**		
	Carroll	1740	**Thunderstorm Wind (G 69)**
4	**Carroll County**		
	Glidden	1745	**Thunderstorm Wind (G 57)**
5	**Hamilton County**		
	2 S Blairsburg	1745	**Thunderstorm Wind (G 65)**
6	**Hamilton County**		
	Ellsworth	1750	**Thunderstorm Wind (G 65)**
7	**Crawford County**		
	1 S Dow City to	1750	**Tornado (F2)**
	11 E Dow City	1809	
8	**Hamilton County**		
	2 SW Williams	1754	**Thunderstorm Wind (G 56)**
9	**Crawford County**		
	Rockwell City	1800	**Urban/Small Stream Flood**
		2100	
10	**Crawford County**		
	Manilla	1800	**Thunderstorm Wind (G 50)**
11	**Franklin County**		
	Hampton	1800	**Urban/Small Stream Flood**
		2100	

<u>Rpt #</u>	<u>Location</u>	<u>Time (UTC)</u>	<u>Storm Characteristic</u>
12	**Hardin County** Iowa Falls	1800 2100	**Urban/Small Stream Flood**
13	**Humboldt County** Dakota City	1800 2100	**Urban/Small Stream Flood**
14	**Pocahontas County** Laurens	1800 2100	**Urban/Small Stream Flood**
15	**Webster County** Ft Dodge	1800 2100	**Urban/Small Stream Flood**
16	**Wright County** Clarion	1800 2100	**Urban/Small Stream Flood**
17	**Boone County** Madrid	1810	**Thunderstorm Wind (G 69)**
18	**Dallas County** Perry	1815	**Thunderstorm Wind (G 74)**
19	**Hardin County** Hubbard	1815	**Thunderstorm Wind (G 50)**
20	**Boone County** 2.5 SE Berkley to 8.5 SE Berkley	1820 1827	**Tornado (F1)**
21	**Grundy County** Conrad	1823	**Thunderstorm Wind (G 61)**
22	**Story County** Story City	1825	**Thunderstorm Wind (G 61)**
23	**Dallas County** 10.5 NW Granger to Granger	1827 1841	**Tornado (F1)**
24	**Boone County** Madrid	1829	**Thunderstorm Wind (G 61)**
25	**Marshall County** Marshalltown Airport	1833	**Thunderstorm Wind (G 57)**

Rpt #	**Location**	**Time (UTC)**	**Storm Characteristic**
26	**Marshall County** Marshalltown	1835	**Thunderstorm Wind (G 56)**
27	**Story County** Colo	1835	**Thunderstorm Wind (G 52)**
28	**Dallas County** Granger	1840	**Thunderstorm Wind (G 87)**
29	**Grundy County** Beaman	1840	**Thunderstorm Wind (G 61)**
30	**Tama County** Gladbrook	1840	**Thunderstorm Wind (G 56)**
31	**Polk County** 5.5 N Grimes to 1 E Des Moines	1841 1905	**Tornado (F2)**
32	**Jasper County** Lynnville	1842	**Thunderstorm Wind (G 56)**
33	**Dallas County** 2 NW De Soto to De Soto	1843 1846	**Tornado (F1)**
34	**Polk County** 4 N Johnston	1843	**Thunderstorm Wind (G 69)**
35	**Marshall County** 5 SW Marshalltown	1845	**Thunderstorm Wind (G 69)**
36	**Tama County** Traer	1845	**Thunderstorm Wind (G 56)**
37	**Jasper County** Sully	1846	**Thunderstorm Wind (G 70)**
38	**Polk County** Ankeny	1846	**Thunderstorm Wind (G 61)**
39	**Polk County** Johnston	1847	**Thunderstorm Wind (G 104)**
40	**Polk County** West Des Moines	1847	**Thunderstorm Wind (G 61)**
41	**Polk County** Urbandale	1848	**Thunderstorm Wind (G 61)**

Rpt #	Location	Time (UTC)	Storm Characteristic
42	**Polk County** Saylorville	1849	**Thunderstorm Wind (G 69)**
43	**Marshall County** 1 E Marshalltown to 2 E Marshalltown	1850 1852	**Tornado (F1)**
44	**Polk County** Des Moines	1850	**Thunderstorm Wind (G 104)**
45	**Marshall County** Marshalltown	1853	**Thunderstorm Wind (G 61)**
46	**Polk County** Des Moines Airport	1854	**Thunderstorm Wind (G 55)**
47	**Polk County** Urbandale	1855	**Thunderstorm Wind (G 61)**
48	**Tama County** Tama	1857	**Thunderstorm Wind (G 69)**
49	**Dallas County** Dallas Center	1900 2100	**Urban/Small Stream Flood**
50	**Jasper County** Newton	1900 2100	**Urban/Small Stream Flood**
51	**Marshall County** Marshalltown	1900 2100	**Urban/Small Stream Flood**
52	**Polk County** Altoona	1900	**Thunderstorm Wind (G 80)**
53	**Polk County** Des Moines	1900	**Thunderstorm Wind (G 80)**
54	**Polk County** Des Moines	1900 2100	**Urban/Small Stream Flood**
55	**Story County** Ames	1900 2100	**Urban/Small Stream Flood**

Rpt #	**Location**	**Time (UTC)**	**Storm Characteristic**
56	**Story County** Nevada	1900	**Thunderstorm Wind (G 56)**
57	**Tama County** Toledo	1900	**Thunderstorm Wind (G 69)**
58	**Tama County** Tama	1903	**Thunderstorm Wind (G 54)**
59	**Polk County** 2 E Des Moines	1905	**Thunderstorm Wind (G 87)**
60	**Polk County** 4 N Johnston	1910	**Lightning**
61	**Warren County** Carlisle	1910	**Thunderstorm Wind (G 56)**
62	**Poweshiek County** Grinnell Airport	1912	**Thunderstorm Wind (G 52)**
63	**Jasper County** Colfax	1915	**Thunderstorm Wind (G 52)**
64	**Warren County** Hartford	1915	**Thunderstorm Wind (G 65)**

# Storm Data for DMX CWA from 1645 UTC through 1915 UTC on 6/29/98
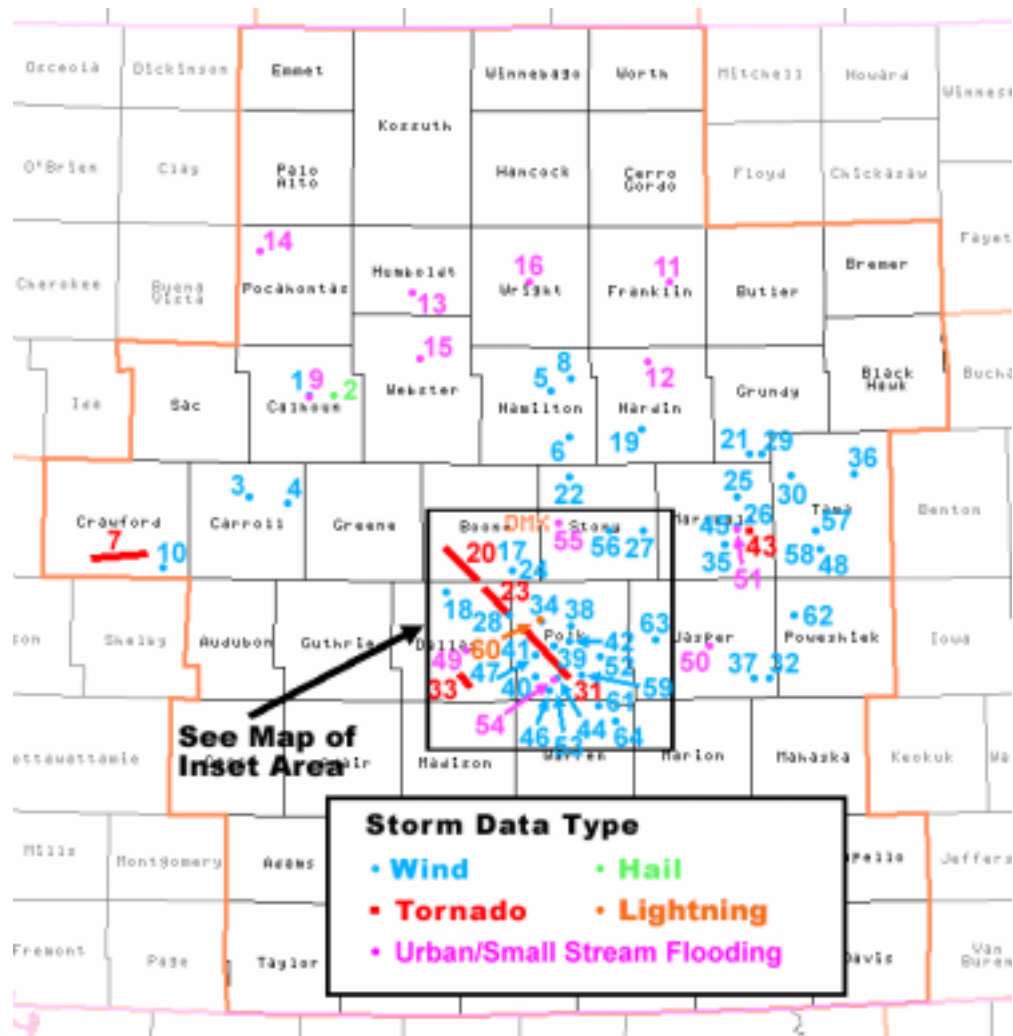
Storm Data for Des Moines Metropolitan Area from 1645 UTC through 1915 UTC on 6/29/98
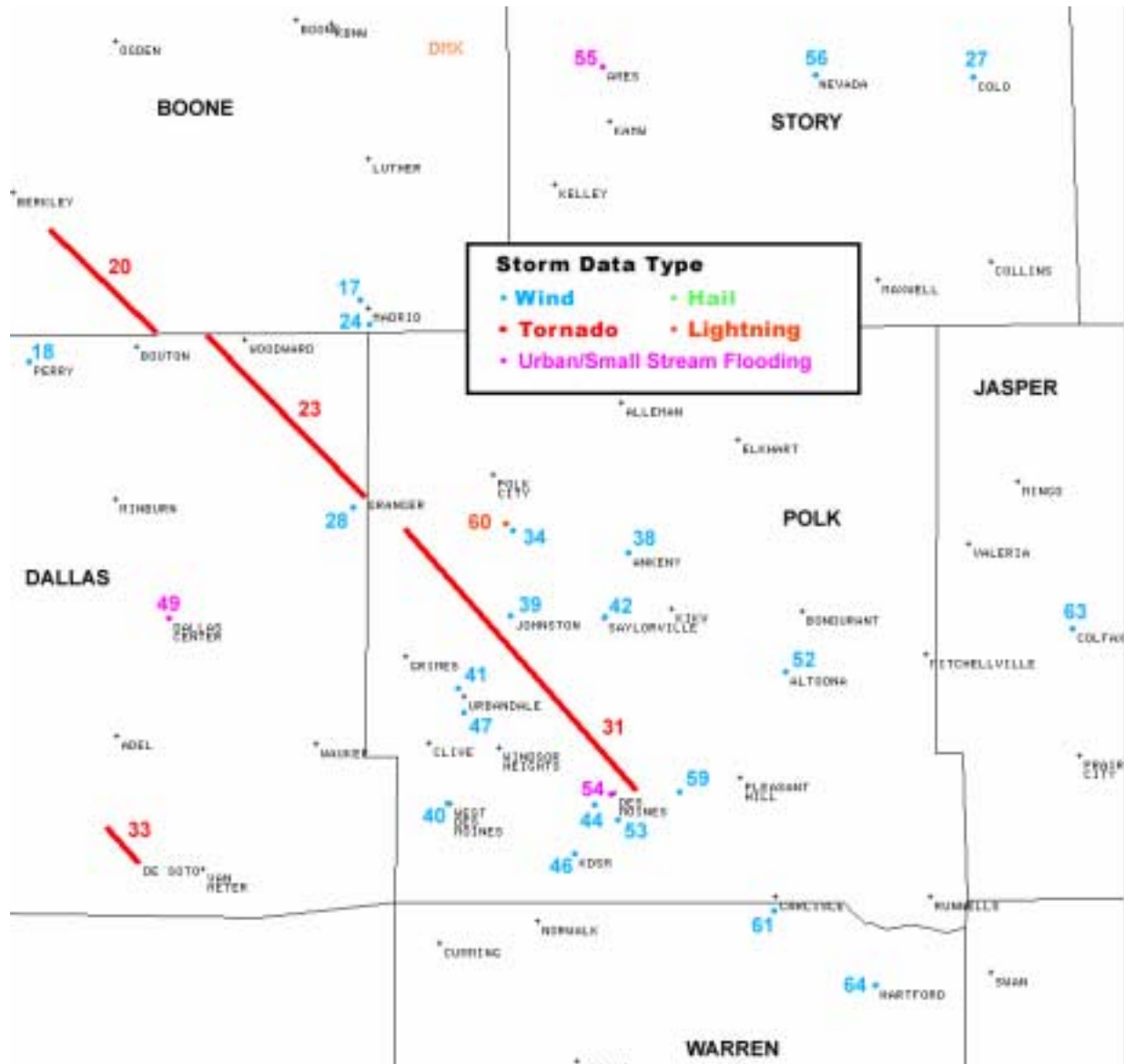
II. DVN CWA Reports

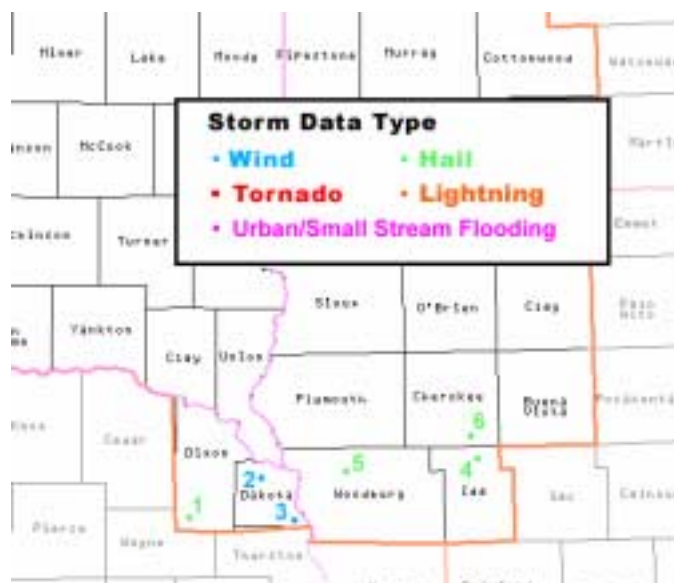| Rpt #	Location	Time (UTC)	Storm Characteristic
1	**Benton County** Countywide	1853 2000	**Thunderstorm Wind (G 70)**
2	**Iowa County** Countywide	1853 2000	**Thunderstorm Wind (G 70)**
3	**Keokuk County** Countywide	1911 2016	**Thunderstorm Wind (G 65)**

Storm Data for DVN CWA from 1645 UTC through 1915 UTC on 6/29/98
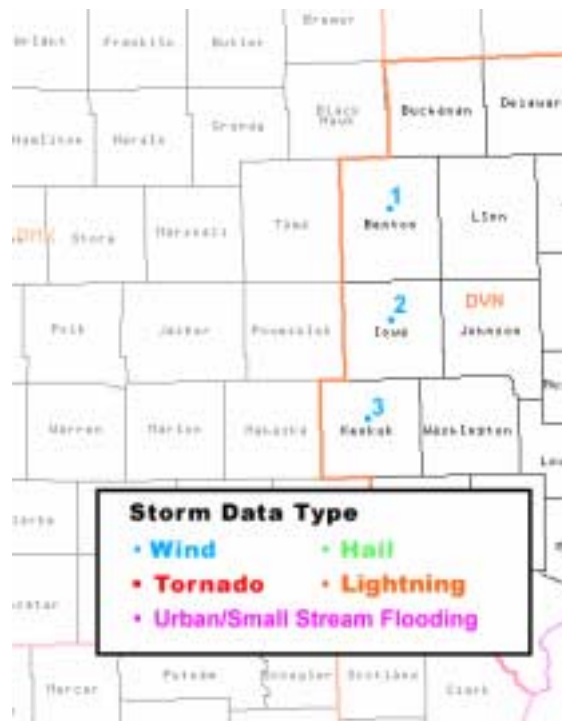
III. FSD CWA Storm Reports

| Rpt #	Location	Time (UTC)	Storm Characteristic
1	**Dixon County** 7 S Concord	1820	**Hail (0.75)**
2	**Dakota County** **1 NW Jackson**	1834	**Thunderstorm Wind (G 52)**
3	**Dakota County** **4 SE Homer**	1846	**Thunderstorm Wind (G 52)**
4	**Ida County** 3 NE Holstein	1650	**Hail (0.88)**
5	**Woodbury County** Lawton	1650	**Hail (0.75)**
6	**Cherokee County** 11 S Cherokee	1705	**Hail (0.75)**

**Storm Data for FSD CWA from 1645 UTC through
1915 UTC on 6/29/98**

IV. OAX CWA Storm Reports

Rpt #	Location	Time (UTC)	Storm Characteristic
1	**Knox County** **6 S Verdel**	1500	**Hail (0.88)**
2	**Knox County** **Center**	1525	**Thunderstorm Wind (G 70)**
	Trees downed. Power outages.		
3	**Knox County** **1 S Wausa**	1545	**Hail (2.00)**
4	**Wayne County** **Carroll**	1620	**Hail (1.75)**
5	**Wayne County** **Wayne**	1625	**Thunderstorm Wind (G 65)**
	Wind damage across much of Wayne County.		
6	**Thurston County** Pender	1645	**Thunderstorm Wind (G 65)**
7	**Burt County** .5 NW Lyons	1700	**Funnel Cloud**
8	**Burt County** Lawton	1712	**Hail (0.75)**
9	**Monona County** 11 S Cherokee	1715	**Thunderstorm Wind (G 65)**
	Trees and power lines downed.		
10	**Monona County** 4 SE Homer	1715 1730	**Thunderstorm Wind (G 65)**
	Widespread trees damaged. Power lines downed.		
11	**Monona County** 3 NE Holstein	1720	**Thunderstorm Wind (G 61)**
	Metal/wood cafe destroyed. Metal grain bin destroyed. Trees downed.		
12	**Monona County** Lawton	1730	**Hail (0.75)**
13	**Monona County** 11 S Cherokee	1730	**Thunderstorm Wind (G 52)**

Storm Data for OAX CWA from 1645 UTC through 1915 UTC on 6/29/98
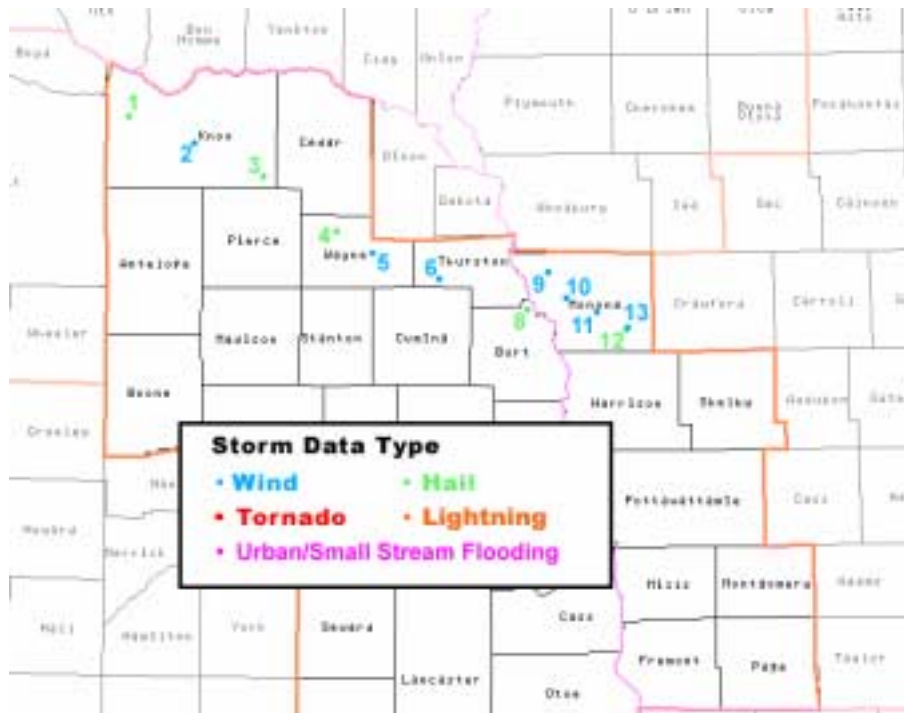
Appendix B: SPC Products

I. Day 1 Convective Outlook

CONVECTIVE OUTLOOK...REF AFOS NMCGPH94O.

VALID 291500Z - 301200Z

THERE IS A MDT RISK OF SVR TSTMS OVER PARTS OF NEB/IA/KS/MO/MN/WI/IL/IND AND KY. THIS AREA LIES TO THE RIGHT OF A LINE FROM OSH 40 WNW BEH DNV LUK 35 N JKL 20 W LOZ BWG 20 NE VIH 10 W FLV LNK 35 SW 3SE RST OSH.

THERE IS A SLGT RISK OF SVR TSTMS TO THE RIGHT OF A LINE FROM ORF 35 NW GSO 40 SE TYS 35 SW CKV 35 NNE UNO 20 N CNU 35 S RSL 35 S HLC 35 ENE GLD 10 SE IML 10 NNW EAR 20 W YKN BKX STC CMX SSM ...CONT... 45 NNE BML LCI PSM.

GEN TSTMS ARE FCST TO THE RIGHT OF A LINE FROM 45 SW P07 20 WNW JCT HEZ 25 E MEI 25 W MSL 30 N DYR 30 NNW JLN 25 ENE GCK 35 SW GLD 30 ESE SNY BBW MHE ATY JMS DIK MLS 35 NNE BZN COD 40 NNW RWL BPI 15 WNW PIH TWF MHS MFR EUG PDX 10 ENE BLI.

ACTIVE SEVERE WEATHER PATTERN THIS PERIOD FROM THE CENTRAL PLAINS AND UPPER MIDWEST TO THE LOWER OH VALLEY/ERN GREAT LAKES. DEEP/ELONGATED SRN CANADA VORTEX EXPECTED TO TRACK SLOWLY E ACROSS SRN ONTARIO ...WHILE ASSOCIATED 75 KT MIDLEVEL SPEED MAX MOVES E ACROSS IA. RICH BOUNDARY LAYER MOISTURE IS IN PLACE FROM THE CENTRAL PLAINS TO THE ERN GREAT LAKES...WITH 850 MB DEWPOINTS ABOVE 12C OVER MUCH OF THE REGION...AND AS HIGH AS 18C NWD INTO NEB/IA.

...LOWER MO VALLEY TO WRN GREAT LAKES...
SATELLITE AND RAOB DATA SHOW 850/700 MB FRONTOGENESIS UNDERWAY AT THE MOMENT ACROSS THE NEB/SD BORDER AREA. THIS FEATURE SHOULD DEVELOP EWD ACROSS IA/SRN MN AND WI LATER TODAY...SERVING AS THE AXIS FOR SEVERE THUN-DERSTORM DEVELOPMENT AS WARM ADVECTION FOCUSES ALONG IT. STRONG UNI-DIRECTIONAL SHEAR PROFILES APPEAR SUPPORTIVE OF SPLITTING SUPERCELLS WITH LARGE HAIL/HIGH WINDS AND POSSIBLY A TORNADO OR TWO...ESPECIALLY GIVEN AMPLE MOISTURE AVAILABILITY AND BROAD PLUME OF STEEP MID-LEVEL LAPSE RATES /APPROACHING DRY ADIABATIC/ SWEEPING EWD FROM THE HI PLAINS. ALTHOUGH LOW-LEVEL CONVERGENCE MAY BE SOMEWHAT WEAK EWD INTO WI...STRENGTH OF SHEAR AND DEGREE OF INSTABILITY SUGGEST A DEFINITE MOD-

ERATE RISK FOR SEVERE.

STORMS WILL LIKELY CONTINUE TO DEVELOP INVOF OF SURFACE COLD FRONT LIN-
GERING BACK ACROSS ERN NEB/WRN IA AND NRN MO THROUGH EARLY TONIGHT.
ALTHOUGH A BIT REMOVED FROM THE STRONGER FLOW FARTHER N...SHEAR WILL
BE SUFFICIENT FOR SUPERCELLS WITH VERY LARGE HAIL/HIGH WINDS AND TORNA-
DOES...ESPECIALLY AS STORMS INITIATE. THIS ACTIVITY WILL LIKELY EVOLVE INTO
AN MCS...WITH BOWS POSSIBLE AS IT MOVES ESE TOWARD THE MID MS/LOWER OH
VALLEYS LATER TONIGHT.


...LOWER GREAT LAKES TO NEW ENGLAND...
VERTICAL SHEAR WILL BE INCREASING FROM SRN MI EWD INTO NEW ENGLAND THIS
PERIOD AS STRONGER UPPER FLOW SPREADS E FROM THE MID WEST. MODEST SUR-
FACE HEATING AND CONVERGENCE ALONG DIFFUSE OUTFLOW BOUNDARIES MAY
INITIATE CONVECTION OVER SRN ONTARIO/WRN AND NRN NEW YORK LATER
TODAY...WHERE CAPE IS SUFFICIENT AND WET BULB ZERO LEVELS ARE LOW ENOUGH
FOR HAIL/LOCALLY DAMAGING WINDS. OTHER STORMS MAY FORM ALONG DEVEL-
OPING WARM FRONT IN ERN NEW YORK. ATLANTIC INFLOW SHOULD KEEP INSTABIL-
ITY SOMEWHAT LIMITED ACROSS MOST OF NEW ENGLAND.

...CENTRAL HI PLAINS...
RICH BOUNDARY LAYER MOISTURE IS IN PLACE ACROSS PARTS OF NEB /PER LBF
RAOB/. SOME OF THIS MOISTURE MAY WORK WWD BEHIND WEAK FRONT DROPPING
S INTO KS. COMBINATION OF FRONTAL CONVERGENCE...UPSLOPE FLOW AND DIUR-
NAL HEATING MAY OVERCOME CAP TO SUPPORT ISOLATED STORMS LATE THIS
AFTERNOON ACROSS PARTS OF WRN KS. IF THEY DO DEVELOP...AGREE WITH GLD
WFO THAT SHEAR WILL BE SUFFICIENT TO SUPPORT SUPERCELLS.

..CORFIDI.. 06/29/98

1528 UTC Convective Outlook on 06/29/98
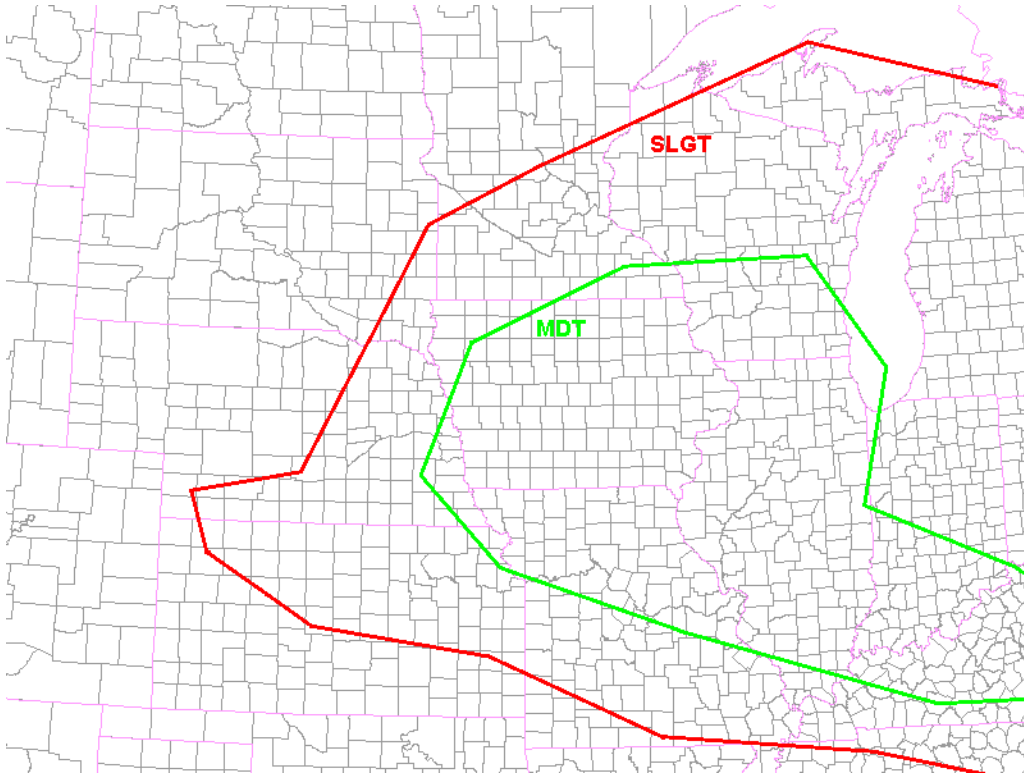
II.   Tornado Watches

WWUS9 KMKC 291601
_MKC WW 291601
IAZ000-NEZ000-292200-

BULLETIN - IMMEDIATE BROADCAST REQUESTED
TORNADO WATCH NUMBER 699
STORM PREDICTION CENTER NORMAN OK
1101 AM CDT MON JUN 29 1998

THE STORM PREDICTION CENTER HAS ISSUED A
TORNADO WATCH FOR PORTIONS OF

  NORTHERN AND WESTERN IOWA
  EASTERN NEBRASKA

EFFECTIVE THIS MONDAY MORNING AND AFTERNOON FROM 1115 AM UNTIL 500 PM
CDT.

TORNADOES...HAIL TO 3 INCHES IN DIAMETER...THUNDERSTORM WIND GUSTS TO 85 MPH...AND DANGEROUS LIGHTNING ARE POSSIBLE IN THESE AREAS.

THE TORNADO WATCH AREA IS ALONG AND 125 STATUTE MILES EAST AND WEST OF A LINE FROM 50 MILES SOUTH SOUTHEAST OF SIOUX CITY IOWA TO 30 MILES NORTH-WEST OF MASON CITY IOWA.

REMEMBER...A TORNADO WATCH MEANS CONDITIONS ARE FAVORABLE FOR TORNA-DOES AND SEVERE THUNDERSTORMS IN AND CLOSE TO THE WATCH AREA. PERSONS IN THESE AREAS SHOULD BE ON THE LOOKOUT FOR THREATENING WEATHER CONDI-TIONS AND LISTEN FOR LATER STATEMENTS AND POSSIBLE WARNINGS.

DISCUSSION...SUPERCELL POTENTIAL LIKELY TO INCREASE EWD ACROSS IA LATER TODAY AS SPEED MAX ROUNDING BASE OF S CENTRAL CANADA UPPER LOW SWEEPS EWD. VERY LARGE HAIL/HIGH WINDS AND ISOLATED TORNADOES POSSIBLE GIVEN DEGREE OF CAPE /ABOVE 4000 J/KG/ AND STRENGTH OF SHEAR /50 KT WNW FLOW AT 500 MB AT THE MOMENT...EXPECTED TO INCREASE TO ABOVE 60 KTS BY THIS AFTER-NOON/.

AVIATION...TORNADOES AND A FEW SEVERE THUNDERSTORMS WITH HAIL SURFACE AND ALOFT TO 3 INCHES. EXTREME TURBULENCE AND SURFACE WIND GUSTS TO 75 KNOTS. A FEW CUMULONIMBI WITH MAXIMUM TOPS TO 520. MEAN STORM MOTION VECTOR 28040.

...CORFIDI

;414,0982 432,0961 432,0911 414,0933;
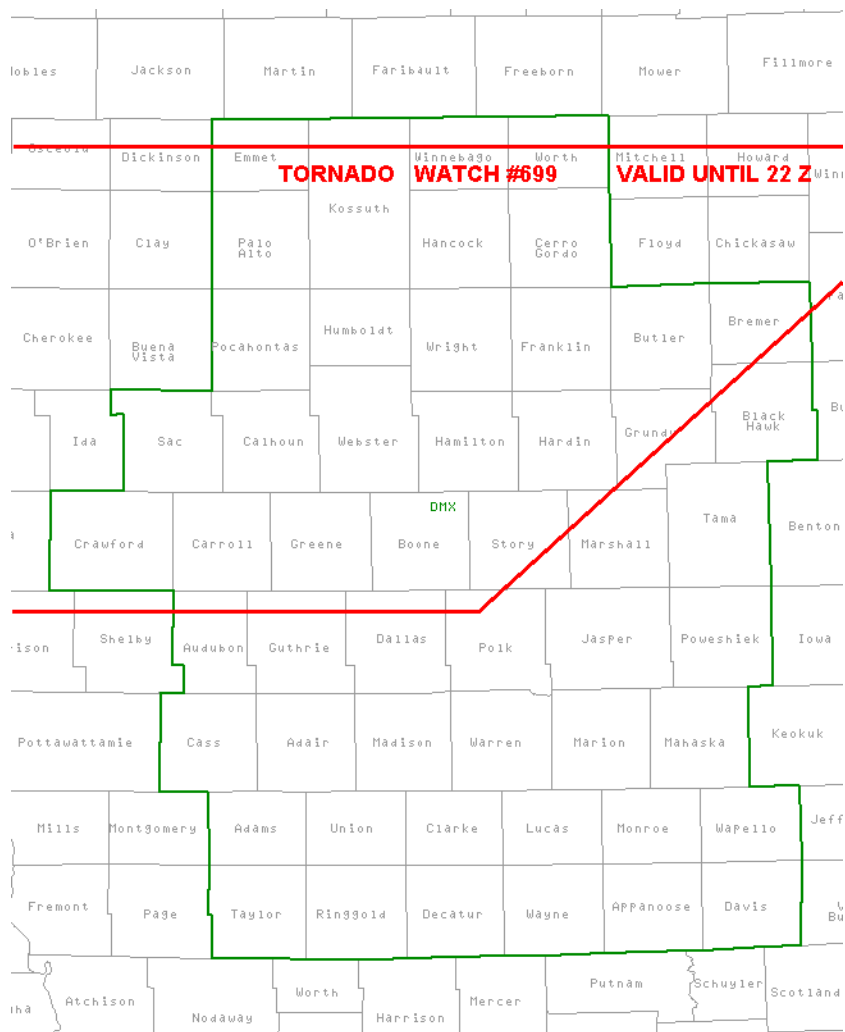
Tornado Watch #699

WWUS9 KMKC 291742
_MKC WW 291742
IAZ000-ILZ000-292200-

BULLETIN - IMMEDIATE BROADCAST REQUESTED
TORNADO WATCH NUMBER 700
STORM PREDICTION CENTER NORMAN OK
1242 PM CDT MON JUN 29 1998

THE STORM PREDICTION CENTER HAS ISSUED A
TORNADO WATCH FOR PORTIONS OF

  SOUTHERN AND EASTERN IOWA
  NORTHWEST ILLINOIS

EFFECTIVE THIS MONDAY AFTERNOON FROM 100 PM UNTIL 500 PM CDT.

TORNADOES...HAIL TO 3 INCHES IN DIAMETER...THUNDERSTORM WIND GUSTS TO 95 MPH...AND DANGEROUS LIGHTNING ARE POSSIBLE IN THESE AREAS.

THE TORNADO WATCH AREA IS ALONG AND 130 STATUTE MILES EAST AND WEST OF A LINE FROM 35 MILES EAST OF LAMONI IOWA TO WATERLOO IOWA.

REMEMBER...A TORNADO WATCH MEANS CONDITIONS ARE FAVORABLE FOR TORNA-DOES AND SEVERE THUNDERSTORMS IN AND CLOSE TO THE WATCH AREA. PERSONS IN THESE AREAS SHOULD BE ON THE LOOKOUT FOR THREATENING WEATHER CONDI-TIONS AND LISTEN FOR LATER STATEMENTS AND POSSIBLE WARNINGS.

OTHER WATCH INFORMATION... CONTINUE...WW 699...

DISCUSSION...SUPERCELLS EXPECTED TO INTENSIFY OVER IA THIS AFTERNOON AS DESTABILIZATION OCCURS IN RESPONSE TO SURFACE HEATING AND DISSIPATION OF OLD OUTFLOW BOUNDARY OVER MO. AMPLE VERTICAL SHEAR IN PLACE TO SUPPORT ROTATING STORMS...WITH 65 KT WNW FLOW EXPECTED TO ENTER WRN PART OF IA BY MID AFTERNOON. SURFACE DEWPOINTS IN THE MID 70S SUG-GEST GOOD TORNADO POTENTIAL DESPITE RELATIVELY WEAK SURFACE-BASED CONVERGENCE.

AVIATION...TORNADOES AND A FEW SEVERE THUNDERSTORMS WITH HAIL SURFACE AND ALOFT TO 3 INCHES. EXTREME TURBULENCE AND SURFACE WIND GUSTS TO 80 KNOTS. A FEW CUMULONIMBI WITH MAXIMUM TOPS TO 550. MEAN STORM MOTION VECTOR 28040.

...CORFIDI

;403,0954 423,0945 423,0895 403,0904;

Tornado Watch #700
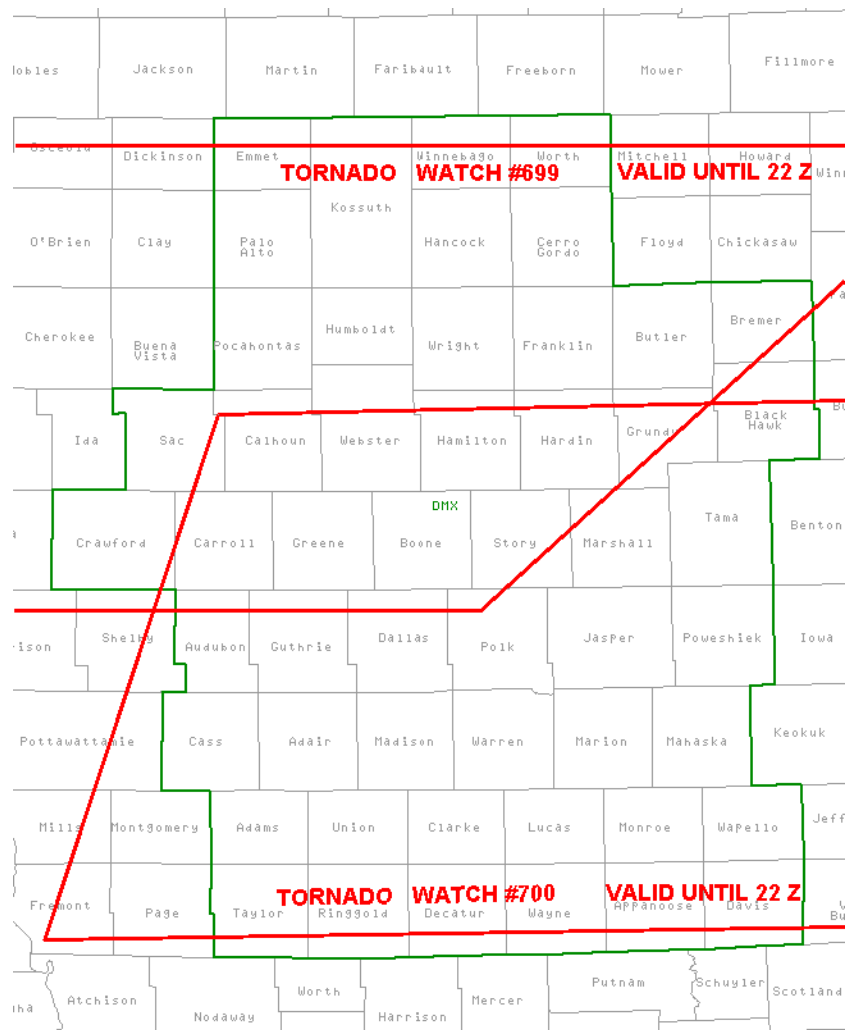
Appendix C: Support Materials

This Appendix includes:

A sample warning log provided for use in the simulations (see page C-2).

A map of the Des MoinesCWA (see Figure C-C-2 on page C-3).

Warning Decision Training Branch

Team Members: **Warning Log**   **Today's Date**

_____/_____   Simulation Location/Date _____   Page #_____

<u>Warning Type</u>	<u>List Basis for Warnings (In order of importance):</u>
Tornado - T	**1 - Reflectivity; 2 - SRM; 3- Base Velocity;**
Svr Tstm - S	**4 - MESO; 5- TVS; 6 - VIL; 7- Precip; 8 - Other Alg**
Flash Flood - F	**9 - Loop; 10 - Report; 11 - Other (explain)**
Svr Wx Statement - SVS	
Nowcast - NOW	

#	Type	Issued (UTC)	Expires (UTC)	Counties or portions of counties warned	init	ver
	Basis:		Location and type of wx expected:			

#	Type	Issued (UTC)	Expires (UTC)	Counties or portions of counties warned	init	ver
	Basis:		Location and type of wx expected:			

#	Type	Issued (UTC)	Expires (UTC)	Counties or portions of counties warned	init	ver
	Basis:		Location and type of wx expected:			

#	Type	Issued (UTC)	Expires (UTC)	Counties or portions of counties warned	init	ver
	Basis:		Location and type of wx expected:			

#	Type	Issued (UTC)	Expires (UTC)	Counties or portions of counties warned	init	ver
	Basis:		Location and type of wx expected:			

#	Type	Issued (UTC)	Expires (UTC)	Counties or portions of counties warned	init	ver
	Basis:		Location and type of wx expected:			

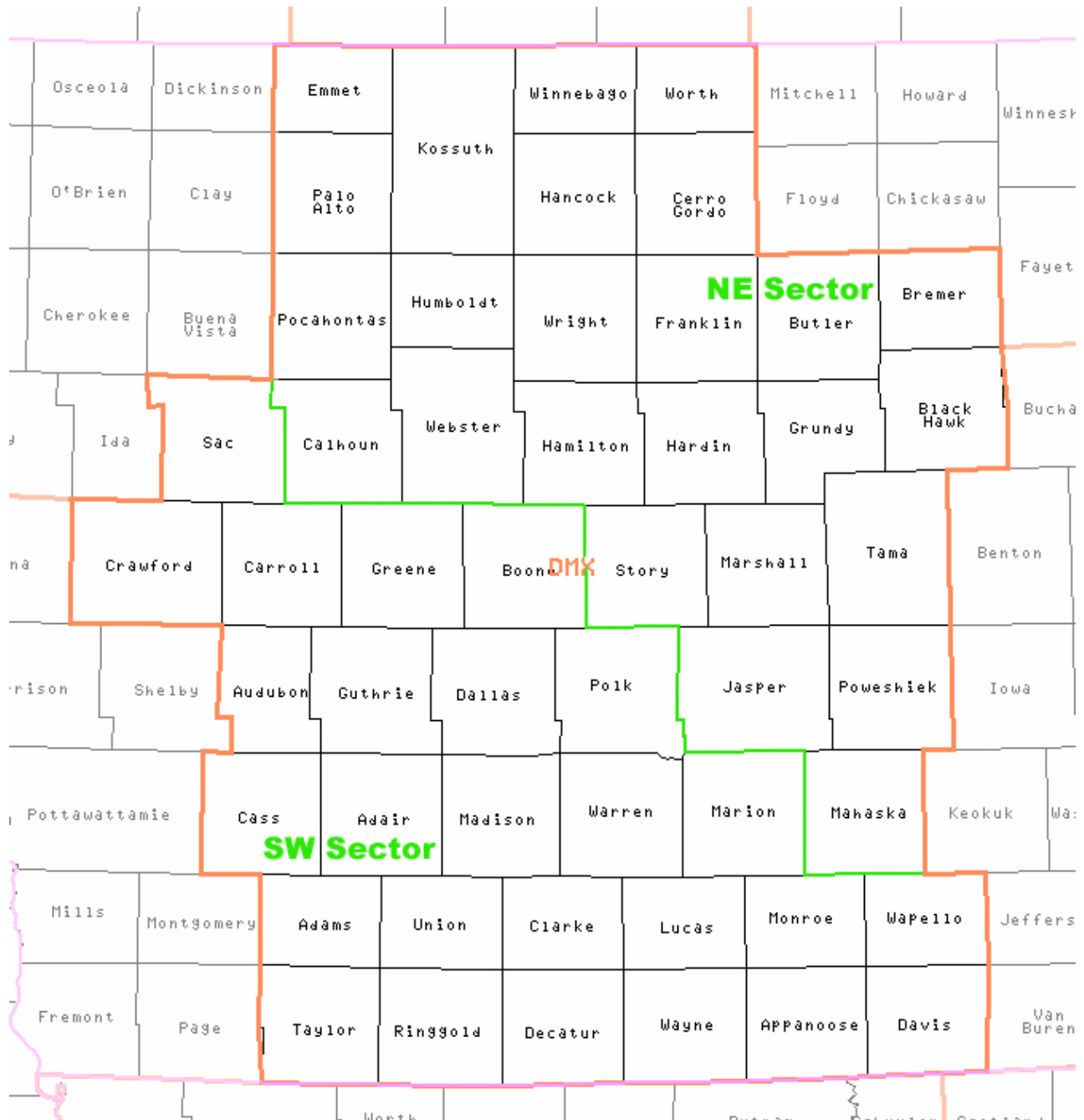| #	Type	Issued (UTC)	Expires (UTC)	Counties or portions of counties warned	init	ver
	Basis:		Location and type of wx expected:			

Figure C-1. Warning Log Form.

Figure C-2. Map of the DMX CWA.